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VOLUME VII

## *Sediment Cores from the North Atlantic Ocean*

FASC. III

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GÖTEBORG
ELANDERS BOKTRYCKERI AKTIEBOLAG

REPORTS OF THE SWEDISH DEEP-SEA EXPEDITION. VOL. VII
SEDIMENT CORES FROM THE NORTH ATLANTIC OCEAN. NO. 3

# DIATOMS FROM EQUATORIAL ATLANTIC CORES

BY

R. W. KOLBE

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## 1. Material

During her cruise round the world the Swedish Deep-Sea Expedition ship »Albatross» crossed the Atlantic three times and collected i. a. a great number of deep-sea cores with the aid of the KULLENBERG sampler, some of the cores discussed in the present paper measuring over 14 m in length. The cruises of the »Albatross» and the distribution of the cores are shown on the chart (fig. 1).

As the object of the present paper was the investigation of the diatoms contained in the sediments of the Equatorial Atlantic, only cores from the southmost cruise have been chosen. The cores taken during this cruise are the ones numbered on the chart.

On first examination, several cores proved to lack diatoms (and other siliceous organisms) altogether. The following cores were finally selected for the investigation; they range from about 30° N to 0° and from about 17° W to 65° W.

Table 1 gives particulars concerning the geographic positions of the cores, the depth of the ocean at these positions and the number of samples from various levels examined. The total number of the cores was 18 and the number of samples 196.

## 2. Methods

After the return of the Expedition the cores were kept in cold storage rooms at the Oceanographic Institute, Göteborg to preserve their natural moisture and to prevent subsequent changes. Samples 1.5 to 2 cm thick were cut out at carefully marked levels (with regard to the complicated and ingenious methods of preserving cores and cutting samples see ARRHENIUS 1952, 4, p. 1). The samples were taken at various levels according to the character of the sediment, usually after a preliminary inspection of different sections of the core.

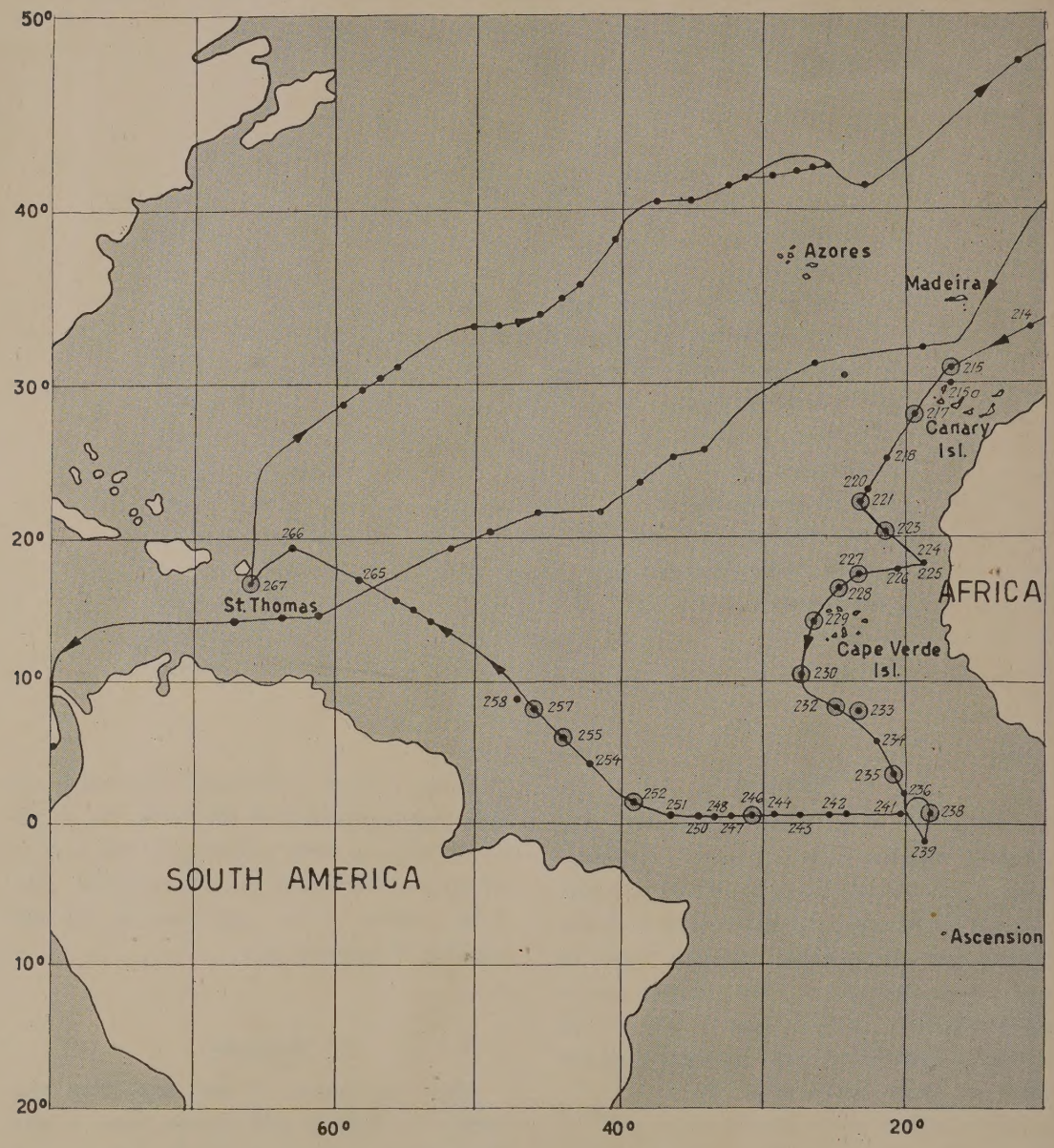


Fig. 1.

Diatoms were very scarce in the Atlantic sediments as compared with the Pacific sediments previously studied (KOLBE 1954). The valves were mostly in a rather poor state of preservation, and after a short treatment with dilute HCl they became soft and their structure indistinct; some of them were totally dissolved (cf. KOLBE 1954, p. 10). The HCl treatment, hitherto successfully used in most cases, had to be abandoned. The removal of the coarser and the finest particles, especially lime and clay, was performed by repeated differential decantations after carefully timed settling periods in glass cylinders 10 cm in height and 4 cm in diameter. Clays and oozes often required 10 decantations or more. The results

TABLE 1.

| Core | Station No. | Geographic position | Depth | Examined section of core | Number of core levels examined |
|---|---|---|---|---|---|
| 215 | 312 | N 29° 55′ W 17° 32′ | 4,320 m | 13— 499 cm | 14 |
| 217 | 315 | N 27° 27′ W 19° 43′ | 4,360 m | 7— 795 cm | 14 |
| 221 | 319 | N 22° 31′ W 23° 28′ | 4,940 m | 7— 568 cm | 6 |
| 223 | 320 | N 20° 21′ W 20° 37′ | 3,820 m | 14— 792 cm | 13 |
| 227 | 324 | N 16° 56′ W 23° 56′ | 3,450 m | 12— 864 cm | 14 |
| 228 | 325 | N 15° 53′ W 25° 27′ | 4,280 m | 13— 392 cm | 3 |
| 229 | 326 | N 13° 37′ W 25° 55′ | 4,910 m | 8— 409 cm | 3 |
| 230 | 328 | N 10° 12′ W 26° 36′ | 5,500 m | 9— 402 cm | 3 |
| 232 | 330 | N 7° 53′ W 24° 43′ | 4,975 m | 1— 152 cm | 3 |
| 233 | 331 | N 7° 13′ W 22° 38′ | 4,125 m | 32—1,456 cm | 21 |
| 234 | 332 | N 5° 45′ W 31° 43′ | 3,577 m | 11—1,451 cm | 19 |
| 235 | 334 | N 3° 12′ W 20° 38′ | 4,560 m | 38— 439 cm | 7 |
| 238 | 339 | S 0° 7′ W 18° 12′ | 7,315 m | 8—1,408 cm | 23 |
| 246 | 350 | N 0° 48′ W 31° 28′ | 3,210 m | 12— 849 cm | 16 |
| 252 | 356 | N 2° 10′ W 39° 6′ | 4,480 m | 33—1,427 cm | 7 |
| 255 | 359 | N 6° 17′ W 43° 20′ | 4,490 m | 12— 402 cm | 2 |
| 257 | 360 | N 7° 29′ W 45° 1′ | 4,470 m | 12— 817 cm | 9 |
| 267 | 369 | N 17° 47′ W 65° 14′ | 2,105 m | 6—1,179 cm | 19 |

were usually not very satisfactory: it was mostly impossible to get rid of a considerable part of mineral fragments etc., and the remaining particles often made it very difficult to photograph the diatoms. But the method did not involve the risk of »losing» or destroying the relatively rare valves and served its purpose of concentrating the material.

After decantation, two drops of an emulsion of the cleaned material were allowed to dry at room temperature on covers 18 × 18 mm square. It is essential, especially for counting, that the valves should be evenly distributed on the covers. To ensure this, a very simple procedure was followed: before using the covers they were strongly heated over the flame of a Bunsen burner until the last traces of fat or oil (always adhering to the covers) had evaporated. After cooling down, a drop of the material emulsion spreads over the whole cover as evenly as if it were alcohol or xylol. Slides were completed in the usual way with Hyrax or Sirax as mounting medium.

In some cases the relative frequency of diatoms had to be expressed in figures. For this purpose the number of diatom valves per slide was determined. This was performed by counting the valves in a field of vision of a measured diameter and by repeating this operation for 10 to 30 fields of vision evenly distributed over the cover. By a simple multiplication the total number of valves per cover resp. slide was fairly well determined. The method is approximate as the concentration of the material may vary to a certain extent in spite of the uniform methods of decantation employed. But it serves its purpose for a rough comparison and orientation.

## 3. Distribution of Diatomiferous Cores in the Equatorial Atlantic

As mentioned above, many cores of the area are practically void of diatoms. In comparison with the East Equatorial Pacific where the sediments are often so rich in diatoms that they could be called »diatom oozes», even the richest cores of the Equatorial Atlantic are characterized by their paucity in diatoms.

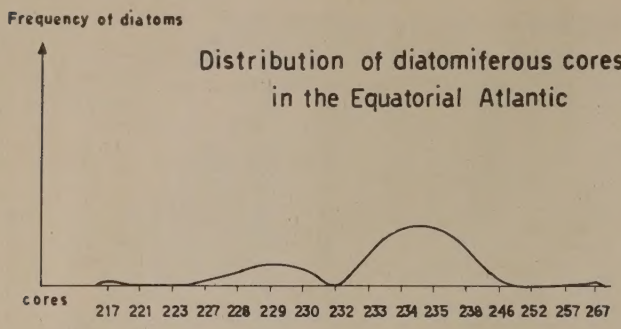
Frequency of diatoms
Distribution of diatomiferous cores
in the Equatorial Atlantic
cores
217 221 223 227 228 229 230 232 233 234 235 238 246 252 257 267

Fig. 2.

Fig. 2 shows the relative frequency of diatom valves in some of the cores examined. It is intended as a general orientation only and is based on estimation. The figure demonstrates that the distribution of the diatomiferous cores in the area investigated has two distinctive features:

1. the cores along the African coast are much richer in diatoms than the cores facing the coast of South America;
2. the maximum frequency of diatoms is to be found in the Cores 233—238.

## 4. Vertical Distribution of Diatoms in the Cores

The distribution of the diatoms at different levels of the cores is very uneven. As stated before, many cores lack diatoms altogether, some cores contain diatoms at their upper levels only, while others, e.g. Cores 233—238, particularly rich in diatoms (see fig. 3), show a very different behaviour with respect to their diatom content. In these cases strong fluctuations in the diatom frequency at different levels are very evident.

In order to study these fluctuations, I selected some of the most characteristic cores and determined the relative frequency (see p. 153, »Methods») in a number of levels in each core. The result is shown in fig. 3.

Fig. 3 represents a selection of cores along the southernmost itinerary of the »Albatross» from Core 215 to Core 267 (cf. chart, fig. 1). The diatom frequency is expressed in average numbers per average field of vision at a given

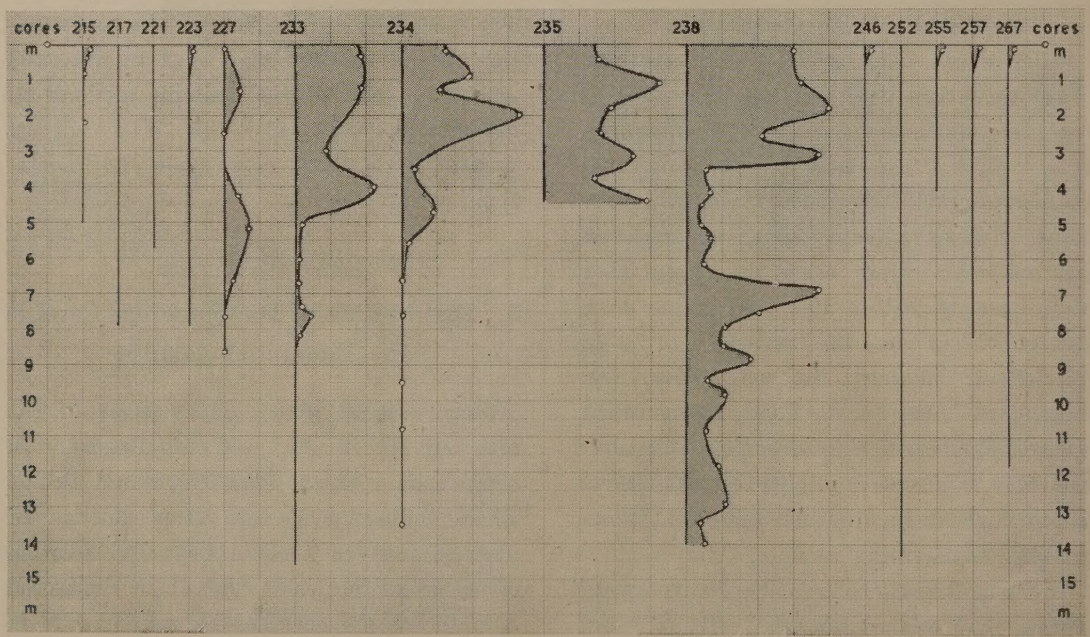


Fig. 3.

magnification (identical for all measurements). The frequency curves are drawn to the same scale and are therefore comparable.

Fig. 3 and its frequency curves show that:

1. Cores 217, 221 and 252 are practically lacking diatoms at all levels; they are either totally void of diatoms or the diatom frequency is so low that it cannot be shown on the scale employed;
2. Cores 215, 246, 255 and 267 contain diatoms at their upper levels only: from a few decimeters or even a few cm depth to the lower end of the core no diatoms could be observed;
3. Cores 227, 233, 234, 235 and 238 (Romanche Deep) show strongly fluctuating curves.

The last group is remarkable in several respects. A more or less sudden drop of the diatom frequency at a sediment depth of about 3—3.5 m seems to be characteristic for all five cores. It is followed (at a sediment depth between 4 and 7 m) by a subsequent pronounced increase of frequency values. This increase rises in core 238 (Romanche Deep) to an abrupt maximum — 12.4 valves per field of vision of 333 $\mu$ in diameter — at about 7 m sediment depth; it is interesting to note that this diatom maximum coincides very closely with the maximum in a curve drawn by MELLIS (personal information) for the size frequency of sediment particles of a given size ($> 6\ \mu$). I take the opportunity of expressing my thanks to Professor MELLIS for his kind permission to use his interesting result.

Cores 235 and 238 show comparatively high frequency values even at their lower ends; Core 235 was unfortunately short so that its behaviour below 4.5 m sediment depth is unknown. Core 234 contained no diatoms below 6 m sediment depth after having shown high frequency values in its upper levels.

The observations discussed above can only be recorded as interesting facts. The temporal changes of the winds and currents and in the physical, chemical and geological conditions prevailing in the ocean at different periods are surely reflected in the diatom frequency in the cores and in the different sediment levels. But it is yet too early to draw any definite conclusions as to the causal connection between these factors and the frequency of diatoms.

## 5. Diatom Assemblages of the Sea Floor

The diatoms of the sea floor do not constitute a natural flora (KOLBE 1954, p. 8), but rather a post mortem formation, a thanatocoenosis. Living diatoms are restricted to the upper euphotic water strata. After their death they are carried by currents and gradually sink to the sea floor. During the long period of transportation, deposition and settling the valves are exposed to the dissolving effects of the sea water, which may vary considerably with respect to its chemical properties. After having been deposited on the sea floor reworking or redeposition of the sediment strata may occur through volcanism and other tectonic agents and this certainly has occurred in the area of the Atlantic where the cores have been taken. As the sedimentation is very slow (in the East Equatorial Pacific, for instance, the rate of accumulation varied from 0.29 to 8.0 cm per 1,000 years) even a short core may comprise a considerable part of the Quaternary Age.

Previous and present physico-chemical conditions in the ocean are not without effect to the »diatom assemblage«[1]) of the sediments (KOLBE 1954, p. 8). A kind of physico-chemical s e l e c t i o n takes place: of the multitude of thin-walled plankton species only a small fraction reaches the sea floor, while coarse forms, perhaps rare in their natural habitats, may become predominant in the sediments.

[1]) I suggested (1954) the term »floral inventory« for a diatom community of the sea floor. As there can be no question of a flora in the orthodox sense of the word in a thanatocoenosis, it is better to substitute the expression »floral inventory« by the non-committal »diatom assemblage«.

It is an interesting problem to compare how much the »diatom assemblages» of the bottom sediments of oceans differ from one another. I suggested (KOLBE 1954) using 8—10 of the most common and widespread forms of an ocean area as a criterion and compared the lists of common forms of the sediments of the Equatorial Pacific and the North Atlantic, the latter having been studied by LOHMAN (1941). A further comparison of these lists with the results of the present investigation is shown below:

TABLE 2.

*Frequency of species*

(in decreasing order of frequency).

| Equatorial Pacific (KOLBE 1954) | Equatorial Atlantic | North Atlantic (LOHMAN 1941) |
|---|---|---|
| = *Coscinodiscus nodulifer* | = *Nitzschia marina* | *Melosira sulcata* |
| = *Fragments (Ethmodiscus?)* | = *Coscinodiscus nodulifer* | + *Thalassiothrix longissima* |
| = *Nitzschia marina* | = *Fragments (50 % = Ethmodisc. rex)* | *Coscinodiscus radiatus* |
| = *Hemidiscus cuneiformis* | *Pseudoeunotia doliolus* | + *Coscinodiscus excentricus* |
| + *Thalassionema* + *Thalassiothrix* | *Coscinodiscus africanus* | + *Coscinodiscus lineatus* |
| *Asteromphalus elegans* | + *Coscinodiscus excentricus* | *Coscinodiscus oculus iridis* |
| + *Coscinodiscus lineatus* | + *Coscinodiscus lineatus* | *Coscinodiscus marginatus* |
| *Asteromphalus hiltonianus* | + *Thalassionema* + *Thalassiothrix* | *Endictya robusta* |
| + *Coscinodiscus excentricus* | = *Hemidiscus cuneiformis* | |
| | *Roperia tesselata* | |
| | *Asteromphalus arachne* | |

Table 2 shows that only three species (marked +) belong to the commonest and most widespread forms of the three areas investigated: *Thalassionema* + *Thalassiothrix* (these 2 diatoms cannot — for practical reasons — be separated here, see the List of Species), *Coscinodiscus excentricus* and *Coscinodiscus lineatus*. The Equatorial Pacific and the Equatorial Atlantic have four species (marked =) in common: *Coscinodiscus nodulifer* (predominant in the Equatorial Pacific, common in the Equatorial Atlantic, rare in the North Atlantic), *Nitzschia marina*, »fragments» (about 50 % of these fragments probably belonging to *Ethmodiscus rex*) and *Hemidiscus cuneiformis*. It can be further seen that the Equatorial areas of the two oceans, the Atlantic and the Pacific, have more forms in common with one another than with the North Atlantic. The main difference between the diatom assemblages of the two Equatorial Oceans is primarily concerned with the frequencies of their common species. While *Coscinodiscus nodulifer* is the predominant form in the Equatorial Pacific cores, *Nitzschia marina* takes this place in the sediments of the Equatorial Atlantic. The genus *Asteromphalus* is represented by two frequent forms: *Asteromphalus elegans* and *Asteromphalus hiltonianus* in the Equatorial Pacific, while these species are rare in the Equatorial Atlantic; on the other hand, *Asteromphalus arachne* and *Coscinodiscus africanus* are common in the Equatorial Atlantic and rare in the Equatorial Pacific cores.

Altogether there is not a very great difference in the diatom inventories of the two Equatorial Oceans apart from the respective frequencies of their species, while the list of diatoms of the North Atlantic shows a greater disagreement with the two lists already mentioned.

A further comparison is not without interest. It concerns

## 6. The »Romanche Deep»

PETIT (1889) studied the diatoms collected during the cruise of the »Romanche» in 1882—83. The »Romanche» sounded the greatest

depth — 7370 m — of the Atlantic known at that time, which was named after the ship »Romanche Deep». The »Albatross» had the good fortune to locate the »Romanche Deep»[1]) and to secure a long core (No. 238) from a depth of 7315 m. As PETIT (1. c.) gave a list of diatoms from the »Romanché» sounding, a comparison of his finds with the diatoms contained in Core 238 can be made. PETIT gives no particulars as to the relative frequency of the species observed; further it is obvious that the core taken by the »Romanche» with the technical resources of that time was of no considerable length. Therefore, to make the comparison as correct as possible, I listed such species only which were met with at 2 levels of Core 238: level 8 cm and level 105 cm from the top of the core.

List of diatom species in the sediments of the »Romanche Deep» collected by:

»Romanche» (1882—83)

*Actinoptychus eummissus*
*Asterolampra variabilis*
**Asteromphalus arachne*
**Asteromphalus elegans*
**Asteromphalus roperianus*
**Coscinodiscus excentricus*
**Coscinodiscus lineatus*
**Coscinodiscus nodulifer*
**Coscinodiscus radiatus*
*Coscinodiscus Rothii* var.
**Hemidiscus cuneiformis*
*Navicula lyra*
*Surirella fastuosa*
*Synedra Sauvinetii*
*Triceratium condecorum*

»Albatross» (1947—48)

*Actinocyclus elongatus*
*Actinocyclus subtilis*
*Actinoptychus undulatus*
**Asteromphalus arachne*
*Asteromphalus cleveanus*
**Asteromphalus elegans*
**Asteromphalus roperianus*
*Biddulphia pulchella*
*Chaetoceros coarctatus*
*Coscinodiscus africanus*
**Coscinodiscus excentricus*
**Coscinodiscus lineatus*
**Coscinodiscus nodulifer*
**Coscinodiscus radiatus*
*Cyclotella stylorum*
*Ethmodiscus rex*
Fragments 1 and 2
**Hemidiscus cuneiformis*
*Nitzschia interrupta*
*Nitzschia marina*
*Pseudoeunotia doliolus*
*Rhizosolenia bergonii*
*Rhizosolenia imbricata* var. *shrubsolei*
*Rhizosolenia styliformis*
*Rhizosolenia styliformis* var. *longispina*
*Roperia tesselata*
*Thalassionema nitschioides*
*Thalassiothrix longissima*
*Triceratium cinnamomeum*
*Triceratium cinnamomeum* var. *minor*

[1]) which was by no means a simple matter, as the Romanche Deep is formed by a relatively narrow and steep crater of a submarine volcano.

Some of the forms in PETITS list are dubious or obsolete, but most of his species (marked by a+) are also to be found in core 238 of the »Albatross» soundings and some of these belong to the more frequent diatoms of this sediment. The similarity between the two lists is therefore noteworthy.

## 7. Benthonic Diatoms

Many diatoms observed in the deep-sea cores of the area are characteristic benthonic forms. As epiphytes attached to various objects, or as motile forms dwelling in the upper strata of the mud, they are dependent on substrata in the photic region and cannot exist in depths exceeding a few 100 m at the utmost. Thus, their natural habitats are the relatively shallow parts of coasts, reefs, estuaries etc.

It is interesting to state which of the cores contained most of the benthonic forms. The following list enumerates the benthonic forms observed and their localities within the present area.

List of benthonic diatoms:

| | Cores No. |
|---|---|
| *Amphora acuta* Greg. | 267 |
| *Amphora crassa* Greg. | 227 |
| *Amphora egregia* (Ehr.) A. Schm. | 267 |
| *Amphora proteus* Greg. | 267 |
| *Amphora spectabilis* Greg. | 267 |
| *Biddulphia pulchella* Gray | 215, 227, 238 |
| *Campylodiscus clypeus* Ehr. | 233 |
| *Campylodiscus echeneis* Ehr. | 227 |
| *Cocconeis britannica* Naeg. | 238 |
| *Cocconeis debesii* Hust. | 227 |
| *Cocconeis heteroidea* Hantzsch | 227 |
| *Cocconeis pinnata* Greg. | 215 |
| *Cocconeis scutellum* Ehr. | 227, 215 |
| *Dimerogramma marinum* (Greg.) Rlfs | 267 |
| *Dimerogramma opulens* Mann | 267 |
| *Diploneis adonis* (Br.) Cl. | 215 |
| *Diploneis bombus* Ehr. | 227 |

*Diploneis crabro* Ehr. ..... 267
*Diploneis fusca* (Greg.) Cl. ..... 227
*Diploneis nitescens* (Greg.) Cl. ..... 215
*Diploneis weissflogii* (A. Schm.) Cl. ..... 233, 235, 238
*Grammatophora marina* var. *tropica* (Ktz.) Gr. ..... 215
*Grammatophora oceanica* (Ehr.) Gr. ..... 267
*Grammatophora oceanica* var. *maculata* (W. Sm.) Gr. ..... 227
*Grammatophora serpentina* (Rlfs) Ehr 215, 227
*Grammatophora undulata* Ehr. ..... 215, 227
*Navicula forcipata* var. *suborbicularis* Gr. .. 215
*Navicula hennedyi* W. Sm. ..... 215
*Navicula lyra* var. *constricta* Per. ..... 267
*Navicula lyra* var. *recta* Grev. ..... 227
*Navicula irrorata* Grev. ..... 267
*Opephora marina* (Greg.) Pet. ..... 227
*Opephora swartzii* (Grun.) ..... 227
*Plagiogramma pulchellum* var. *pygmaeum* (Grev.) Per. ..... 227
*Raphoneis amphiceros* Ehr. ..... 227
*Raphoneis belgica* Grun. ..... 215
*Rhabdonema adriaticum* Ktz. ..... 227
*Rhabdonema arcuatum* Ktz. ..... 227
*Scoliopleura tumida* (Breb.) Rabh. ..... 215
*Stictodiscus parallelus* f. *hexagona* (Castr.) 215
*Surirella fastuosa* Ehr. ..... 227
*Surirella fastuosa* var. *cuneata* Aar. Schm. 238
*Surirella fluminensis* Grun. ..... 215
*Trachyneis aspera* var. *oblonga* (Breb.) Cl. .. 227
*Trachyneis aspera* var. *vulgaris* Cl. ..... 223
*Triceratium alternans* Bail. 215, 223, 227, 267

Summing up the numbers of benthonic forms contained in each of the localities specified, the following figures are obtained:

Core 227 contains 22 benthonic forms
Core 215 contains 15 benthonic forms
Core 267 contains 12 benthonic forms
Core 238 contains 4 benthonic forms
Core 233 contains 3 benthonic forms
Core 223 contains 2 benthonic forms
Core 235 contains 1 benthonic form

There is a great difference between the first 3 and the last 4 cores in respect to their content of benthonic forms; it can be assumed that the benthonic diatoms in the last 4 cores were ± accidental.

The first 3 cores show an unusual number of benthonic diatoms and these cores were taken in the vicinity of the only islands approached by the »Albatross» on the itinerary investigated in the present paper, viz.:

Core 227 near the Canary Islands although at a depth of 3450 m.

Core 215 near the Cape Verde Islands although at a depth of 4320 m.

Core 267 near the Island of St. Thomas at a depth of 2105 m.

Of course, the result of this statistical study is not unexpected, but it proves that the proximity of shores offering natural habitats to benthonic forms can easily be traced even in deep-sea sediments.

There is — last, but by no means least — yet another peculiarity of the Equatorial Atlantic sediments which deserves a more detailed treatment, viz. the frequent occurence of freshwater diatoms in the cores.

## 8. Freshwater Diatoms in Atlantic Deep-Sea Cores

One of the most striking peculiarities of the Atlantic sediments from the »Albatross» cruise is the constant occurence of freshwater diatoms in practically all diatom-bearing cores studied. Some of the cores show no trace of diatoms; nor do these sediments contain other remains of siliceous organisms (radiolaria, silicoflagellata). It is probable that this fact is due to certain local physico-chemical effects of the sea water on the sediments (high pH-values, etc.) resulting in a complete corrosion and destruction of the remains of siliceous organisms.

The majority of the cores, however, contained more or less numerous diatom valves. As could well be expected, marine plankton forms prevailed, whilst in some near-shore cores some benthonic diatoms could be observed, but a small percentage of freshwater species was practically a l w a y s present.

The constant occurence of freshwater species — even in all diatomiferous off-shore sediments — is a rather unexpected phenonomenon and might suggest an introduction of such forms through a faulty technique. I think that this suspicion can be excluded for two reasons: all glass vessels and instruments were always meticulously cleaned; they were, besides, for three years exclusively used for work on Equatorial Pacific materials, which contained absolutely no freshwater forms. Finally: the extraordinarily high frequency of *Melosira granulata* (see below) proves without doubt the impossibility of an accidental contamination of the samples or the slides with freshwater forms.

More than 60 freshwater species could be observed in the Atlantic sediments studied. The species belong to very different ecological groups: plankton and benthonic forms, species typical for eutrophic and even dystrophic habitats. In most levels only a few (5—50) valves per slide could be observed, each slide being prepared from a highly concentrated and enriched sediment (see p. 152). The most frequent freshwater diatom was *Melosira granulata* (Ehr.) Rlfs. with its varieties. It was the form which showed the most constant occurence in practically all levels of the cores. Its frequency was truly astonishing: it sometimes amounted to more than 1,000 valves per slide and in one instance about 3,600 valves per slide could be counted (see p. 180 »*Melosira granulata*»).

A paradoxical observation may be mentioned: a certain level (552 cm below the top of Core 234) contained freshwater diatoms e x c l u s i v e l y, with the only exception of a single fragment of a marine form. This level almost gave an impression of belonging to a freshwater sediment. Apart from the ever-present *Melosira granulata* not less than 17 other freshwater species could be noted. This »freshwater community» seemed restricted to a thin stratum: the next higher level contained the usual diatom assemblage (marine forms and — rarely — *Melosira granulata*), while the next lower level held no diatoms at all with the exception of a fragment of — typically enough — *Melosira granulata*.

In itself the presence of freshwater diatom in oceanic sediments is nothing new. Among former stray observations I mention Grunow (1884) who found *Melosira granulata* in a couple of »Tiefseegrundproben» off Franz-Josefs Land; Edwards (1897) listed »*Cyclotella astraea*» (= *Stephanodiscus astraea*) in two sediments samples collected by the »Tuscarora» Expedition. Lohman (1941) observed *Melosira granulata*, *Stephanodiscus astraea*, *Eunotia praerupta* and *Rhoicosphenia curvata* in several sediment samples from the North Atlantic. It appears from his paper that his finds were restricted to a few cores and that the freshwater forms were very rare.

In comparison with these statements my observations do not only confirm the presence of freshwater forms in Atlantic sediments but reveal their relatively high f r e q u e n c y and their c o n s t a n t o c c u r e n c e in most diatomiferous cores studied, the deep-sea and off-shore cores included. The Atlantic cores examined cannot surely be considered as near-shore sediments, most of the cores being collected at mid-ocean positions. The table below shows the approximate distances from the nearest shores for three of the cores which were richest in freshwater diatoms.

As already has been pointed out, *Melosira granulata* (including some of its varieties) was the most frequent form in the sediments studied. Next to it in frequency came: *Melosira ambigua*, *Stephanodiscus astraea*, *Epithemia argus* and

TABLE 3.

| Core No. | Geographic position | Distance from the nearest shore | |
|---|---|---|---|
| | | in Africa | in South America |
| 234 | N 5° 45′ W 21° 43′ | 930 km | 1,960 km |
| 235 | N 3° 12′ W 20° 25′ | 990 km | 1,900 km |
| 238 | S 0° 7′ W 18° 12′ | 1,050 km | 1,990 km |

*Cymbella turgida.* It is typical that the forms mentioned are cosmopolitan and belong to the most common diatoms in eutrophic waters. *Melosira granulata* is exceedingly common in eutrophic rivers and lakes throughout the world. *Melosira ambigua* is very frequent in the tropical zone. HUSTEDT (1949) studied the diatoms of the Belgian National Park (tropical Africa) and writes about this form: »Sie ist bei weitem die häufigste der pelagischen Arten des untersuchten Gebiets.»

The cores having the highest frequency of *Melosira granulata* are Cores 229, 230 and more especially Cores 234 and 235; the latter 2 cores also contain the greatest number of freshwater species besides *Melosira.* The first appearance of *Melosira* could be observed in Core 217; westward of Core 252 it is no more found, but the cores of this area are practically void of all diatoms — marine or freshwater.

A very interesting observation must be mentioned although, strictly speaking, it is rather out of place in a report on diatoms. It is the very frequent occurrence of silicified epidermal cells of *Cyperaceae* and *Gramineae.* It seems that, so far, they have been overlooked: to the best of my knowledge no mention of them is to be found in reports on deep-sea or other sediments. The siliceous epidermal cells, »Kiesel-Kurzzellen» (GROB 1896) or »cellules courtes» (PRAT 1935) are very characteristic (see »Appendix», p. 181 and figures, pl. II, fig. 12—17) and hardly to be mistaken for any other siliceous remains. I have observed them very often in freshwater sediments. They are short epidermal cells, whose whole interior becomes silicified during the life of the plant, and the resulting compact siliceous »casts» are obviously very resistant to the effects of sea water after the death and the decay of the plant. They were observed in most of the Atlantic cores and their frequencies were second only to those of *Melosira granulata.*

## Origin of freshwater diatom sediments in Atlantic cores.

It is obvious that the valves of freshwater forms met with in oceanic sediments originate from continents or islands, as no freshwater diatom can survive, let alone reproduce in sea water. Therefore the problem of transportation of these forms from their natural habitats to the marine sediments is the one to be discussed. Enormous quantities of freshwater diatoms must have been removed from their land habitats, carried away and finally deposited at distant parts of the sea floor. Two possibilities are open for the transportation of great masses of material from land to sea: transportation by rivers (potamic transport) and by wind (aeolian transport).

Potamic transport appears to offer the most obvious and natural explanation of the problem. In our special case it suggests itself: a few great rivers (the Niger, the Congo) and very many more or less small streams flow into the Gulf of Guinea or south of it. The rivers are fed by almost innumerable tributaries which may carry diatoms or their valves from lakes, swamps etc. This would easily explain the presence of diatoms of different ecological types as found in the deep-sea cores. Once in the sea, the suspended valves would be taken up by currents: in the present case by the Benguela, the South Equatorial and the Guinea Currents. As the sinking of the diatom valves surely takes a very long time during which a constant horizontal transport takes place, the final deposition of the valves may occur at distant off-shore localities. The rivers would also carry remains of dead plants, such as *Gramineae* and *Cyperaceae;* their silicified epidermal cells would meet the same fate as the diatom valves.

Hitherto I have only mentioned the African rivers, as I do not believe that the South American river system has any notable influence on the sediment of the area examined. The

direction of the currents and the trade winds points in favour of the African rivers. The cores collected in front or in the neighbourhood of the mouth of the Amazon were unfortunately void of diatoms so that no direct observations could be made.

My assumption goes well with a remark by F. Koczy, who studied the sedimentation and geochemistry of the Equatorial Atlantic Ocean. Koczy (1950, p. 22) writes:

»Das Guineabecken ist durch eine extrem hohe Sedimentationsgeschwindigkeit ausgezeichnet, die wohl hauptsächlich auf die Zufuhr des Niger zurückzuführen sein dürfte. Dagegen scheint das terrigene Material, welches vom Amazonas transportiert wird, vom äquatoriellen Strom nach Norden transportiert worden zu sein. Südlich der Kap Verde Inseln findet man die grösste Sedimentation des ganzen untersuchten Bereichs.«

Koczys investigations have also showed that the maximum sedimentation takes place in a district south of the Cap Verde Islands. In their turn, my studies on the Atlantic diatoms confirm Koczys statement, as the cores richest in diatoms were situated in the same area of the Equatorial Atlantic, while those facing the Amazon held practically no diatoms.

Aeolian transport. The transportation of great quantities of diatoms by wind would not seem very probable, were it not for the particular geographic position of the majority of the present material. The West Coast of Africa is entirely in the zone of influence of the desert winds which periodically carry large quantities of fine sand and dust particles. The strong influence of the dust storms is best illustrated by the ill fame of certain districts of the Atlantic near and south of the Cap Verde Islands. Early navigators feared this near-shore part of the Atlantic (from about lat. 30° N to lat. about 5° S) and this sector was called »the Dark Sea», »Dunkelmeer» and »Pot-au-Noir». At certain periods the fine dust carried by the NE trade

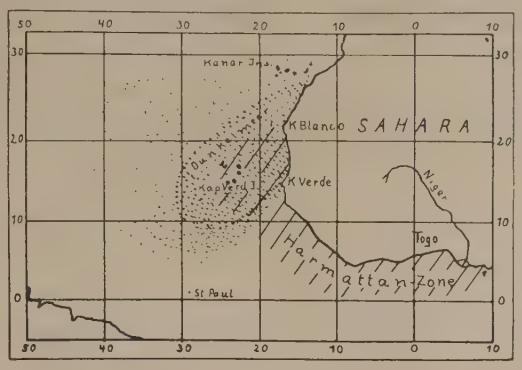


Fig. 4. (after Pratje)

wind blowing from the Sahara Desert produces a haze, reducing the visibility at sea to 1—1½ km and in some cases even to 150 m (Pratje 1934, p. 179). According to this author, from whose paper I summarize the following information, the Sahara dust has been analyzed and found to contain mineral particles only. The Sahara dust is responsible for some mineral sediments in the deep-sea cores, but probably not for the freshwater diatoms which these cores contain.

South of the district discussed and overlapping it, another dust phenomenon is well known, although not so feared as the Sahara haze. It is the »Harmattan» haze; it is caused also by the NE Trade. Its zone extends from about 15° N almost to the Equator (see fig. 4). »Harmattan» haze (or dust) has been analyzed by Hustedt (1922) and was found to consist mainly of diatom valves and their fragments. Hustedt gives a list of 51 freshwater diatoms (varieties excluded), mostly common cosmopolitan forms. About half of them (25) were found in our sediments too.

The places of origin of the »Harmattan» diatoms are supposed to be the dry but periodically inundated swamp districts of the Niger and its tributaries. The NE Trade often causes prairie fires, and the ashes of burnt plants are one of the components of the »Harmattan» dust. This could explain the presence of the silicified epidermal cells in the sediments.

Koczy (1950, p. 28, fig. 9) gives a map of the zone of maximum sedimentation (of $Fe_2 O_3$) in the Equatorial Atlantic. His map is more or less identical with Pratjes (1934; see also the present paper, fig. 4) and demonstrates a further interesting parallel between winds and sediments.

The potamic and aeolian hypotheses thus seem to be of equal significance to the question of the freshwater diatoms in Atlantic cores. I think the question may be summarized as follows: a l l valves of freshwater diatoms discharged by both wind a n d rivers are finally deposited on the sea floor after having been carried ± far off by sea currents. It is impossible at present to state if the winds or the rivers deliver the bulk of the material for the freshwater diatom sediments, and this question seems to be of no great importance. Personally I do not hesitate to ascribe the more important rôle to the potamic transport. The »Harmattan» wind only blows periodically, while the rivers, streams and rivulets deliver their load of diatoms constantly into the sea. We have no relative figures as to the weight or volume of solid matter carried by the »Harmattan» wind. I cannot imagine that such figures could be compared with the enormous quantities of plankton and seston discharged by the rivers at any moment into the Gulf of Guinea, although I am well aware that such speculations are only guesswork.

Some of the geographic conditions of the West Coast of Africa are repeated on the West Coast of South America. A great continent slopes down to an ocean and currents in this district are similar to those off the West Coast of Africa: the Peru Current flows from S to N like the Benguela Current and runs into a South Equatorial Current flowing equally from E to W. Parts of the West Coast of South America are arid and of a desert character. The winds of this part of the globe present a marked similarity to those of the corresponding part of Africa. In a geographical sense, cores taken around the Galapagos Islands are the counterpart of the cores collected around the »Romanche Deep».

It might perhaps be expected that these Pacific cores would contain freshwater diatoms like the sediments of their African counterpart. This is not the case, however: neither the Galapagos cores nor any other Equatorial Pacific cores collected by the »Albatross» contained a single freshwater species. This fact is most probably due to the complete lack of larger rivers along the West Coast of South America and also to the arid character of the greater part of this coast as opposed to the swampy character of the corresponding part of the West Coast of Africa.

## 9. Pre-Quaternary Diatoms

Some of the cores collected by the »Albatross» in the Equatorial Pacific contained a number of doubtless extinct Pre-Quaternary diatoms at a certain, not even very considerable depth of the sediment (Kolbe 1954, p. 19). While examining the present Atlantic cores great care was taken not to overlook extinct forms, if present. The result was entirely negative. No Pre-Quaternary forms could be observed in any of the cores or levels of the area investigated.

The negative result was somewhat unexpected, as specialists surveying »Albatross» material from the same area have observed a number of extinct foraminifera. It is difficult to find an explanation for these contradictory results: the absence of extinct diatoms, while extinct foraminifera have been found in the same area.

Two facts, previously discussed, may help in finding an answer to this question:

1. It has been stated before that diatom valves from most cores of the area were not in a good state of preservation and could not stand the usually harmless treatment with

dilute HCl. Although typical signs of corrosion were rare and the sculpture of the valve could be identified, the details were blurred and the valves seemed thinner than normally. After treatment with dilute HCl the valves became soft, they crumpled easily and behaved altogether like soft pellicles. There only seem to be two reasons for this behaviour: either the silicified valve membranes were in a more or less advanced state of de-silification (solution of the siliceous compounds of the membrane) or that the living diatoms in the Equatorial Atlantic had thinner or less silicified membranes than in other seas (e. g. in the Equatorial Pacific) — an assumption which seems highly improbable.

2. Most diatomiferous cores of the area contained diatoms in their superficial layers only, while deeper levels were practically lacking in diatoms. Cores 227, 233, 234 and 235 contained diatoms up to a sediment depth of 5—8 m, but the deeper levels held no diatoms like the rest of the cores, with the exception of Core 238.

Core 238 had a relatively high diatom frequency at 14 m depth of sediment (end of core). But it should be born in mind that this core (Romanche Deep) represents a deep crater with steep walls. It is probable that the sedimentation at that point takes place in a different manner to that in the adjacent ± flat regions of the sea floor. Great quantities of the surrounding superficial sediment may be constantly swept into the crater by deep underwater currents. Therefore the lower layers collected by the KULLENBERG sampler may be of a more recent date and consequently in a relatively good state of preservation.

If we accept these deductions, the lack of Pre-Quaternary diatoms in the area may be explained by the strong corrosion effects to which the dead diatoms are exposed during their sinking to the sea floor and especially after their final settling in the sediments. This last statement, strengthened by the lack of diatoms at deep sediment levels, of the Atlantic leads to the conclusion that all diatom valves in certain parts of this ocean, even those having reached the sea floor, may be entirely dissolved after a certain long lapse of time and that no Pre-Quaternary diatoms can be expected to be found in deep sediments of the area investigated. On the other hand, the foraminifera are destroyed by other chemical agents than the diatoms: low pH, for instance, is detrimental to foraminifera and indifferent to diatoms, while high pH-values have the opposite effect. In certain cases, as probably in the present one, foraminifera tests might have been preserved while diatoms were totally dissolved.

These conclusions hold true for undisturbed sediments. Geological investigations may yield further important aspects to these interesting questions.

## 10. List of Species

Genera and species have been enumerated in alphabetical order in this paper; this makes the usual index unnecessary and facilitates references.

The localities are often indicated by two numbers, the first representing the number of the Core and the second the depth of sediment in cm from its surface. Only such diagnoses and figures are cited which, in the authors opinion, were best or came nearest to a form in question. The Rules and Recommendations of the 7th International Botanical Congress have been followed with respect to the orthography of latin names.

Marine and freshwater diatoms were listed separately in order to give a better idea of their relative number and distribution.

An Appendix dealing with silicified epidermal cells has been added.

## A. MARINE SPECIES

### Actinocyclus Ehr.

*Actinocyclus ehrenbergii* var. *crassus* (W. Sm.) Hust.

Van Heurck 1880, pl. 124, fig. 6, 8.

Peragallo 1897, pl. 114, fig. 3, 4.

Hustedt 1927, I, p. 530.

Very rare; a few valves observed in some levels of core 235.

*Actinocyclus ehrenbergii* var. *tenellus* (Breb.) Hust.

Peragallo 1897, pl. 113, fig. 7

Hustedt 1927, I, p. 530.

A single valve in core 235/314.

*Actinocyclus elongatus* Grun.

Synonym: *Actinocyclus ellipticus* var. *elongatus* (Grun.) Kolb.

Kolbe 1954, p. 20, pl. III, fig. 28.

Icon nostr. pl. II, fig. 20.

In my survey of the diatoms from Pacific cores (l. c.) I looked upon this species as a variety of *Actinocyclus ellipticus* on account of the ± frequent transitional forms (including *Actinocyclus ellipticus* f. *lanceolata*) which seemed to connect it with the typical form, *Actinocyclus ellipticus*. Both the typical form, transitional forms and especially the »variety» *elongatus* were fairly frequent in the Pacific cores. The Atlantic cores showed a totally different aspect: while the »variety» (*Actinocyclus elongatus*) was present in most of the cores, the typical *Actinocyclus ellipticus*, the transitional forms and f. *lanceolata* were totally lacking in this material. Moreover *Actinocyclus elongatus* (the former »var. elongatus») was so constant with regard to its shape and structure — identical in both with Grunows figures (Van Heurck pl. 125) — and showed so little tendency to variation that I consider it better to look upon the form as a s p e c i e s. I suggest therefore to draw in the name *Actinocyclus ellipticus* var. *elongatus* and to consider *Actinocyclus* (?) *elongatus* Grun. (Van Heurck 1881, pl. 125, fig. 15, 16, 17) as a »good» species. *Coscinodiscus* (?) *elongatus* Grun. (Van Heurck 1881, pl. 125, fig. 14) seems to me doubtless the same form: it is very probable that Grunow could not discern the very small ocellus with the instruments of his time.

It is paradoxical to place slender, almost rod-like forms like *Actinocyclus elongatus* in the genus *Actino c y c l u s*. The entire group of elongated *Actinocycli* (and *Coscinodisci*) is in urgent need of a modern revision. Until then I consider any attempt to make taxonomical amendments of single species as unsuitable and prefer to leave the present form in its unsatisfactory systematic position for the time being, at all events.

*Actinocyclus elongatus* is a very characteristic form; its outline varies more than its structure. In the present material extremely long forms (up to 176 $\mu$ in length, see pl. II fig. 20) could be observed occasionally. It belongs to the species having a wide distribution in the area.

Localities: cores 227, 233, 234, 235, 238 in many sediment levels.

*Actinocyclus subtilis* (Greg.) Ralfs var. (?)

Rattray 1890, p. 188

Peragallo 1908 pl. 114, fig. 5, 6

Hustedt 1927, I p. 534.

Practically all individuals observed in the Atlantic sediments (as well as formerly in the Pacific cores) did in certain respects not fully agree with the diagnoses. Mr. Hendey kindly communicated me material from Kuwait (Persian Gulf) from which I could study very typical individuals fully agreeing with the descriptions and figures by Rattray and Hustedt (l. c.). Considering the constant occurence of the divergencies in my material (I have observed many hundreds of individuals) it seems to me important to show the main points of difference between the »classical» specimens and individuals from my material:

*Actinocyclus subtilis*

Typical forms from Kuwait:

*Size:* average diameter about 100 $\mu$.

*Areolation:* 14 to 16 areolae in 10 $\mu$. rows of areolae very dense.

*Central area:* distinct, bearing minute granules and circumscribed by a narrow hyaline zone.

*Ocellus:* large, distinct, sharply circumscribed by hyaline irregular space.

Forms from the Atlantic and Pacific:

*Size:* diameter: 30 to 70 $\mu$.

*Areolation:* areolae: 10 in 10 $\mu$, very rarely up to12 in 10 $\mu$. rows of areolae rather sparse.

*Central area:* indistinct or absent.

*Ocellus:* very small, no hyaline space.

The individuals from the Atlantic may be a variety of *Actinocyclus subtilis*. As I do not know the range of variation of the species I list it as var. (?).

*Actinocyclus subtilis*, although never frequent, is one of the constant and widely spread forms in the Equatorial Atlantic cores. Localities: cores 215, 227, 233, 234, 235, 238 in many sediment levels.

**Actinoptychus** Ehr.

*Actinoptychus splendens* (Shadb.) Ralfs
Hustedt 1927, I, p. 478.
A few specimens in cores 227 and 233.
*Actinoptychus undulatus* (Bail,) Ralfs
Van Heurck Syn., pl. 122, fig. 1, 3.
Hustedt 1927, I, p. 475.

Widely distributed throughout the area, though never frequent. Small specimens predominant.

Localities: cores 215, 223, 227, 233, 234, 235, 238.

**Amphora** Ehr.

The following 5 species were mostly found in a near-shore core ± close to the island of St. Thomas, thus demonstrating the benthonic character of the genus.

*Amphora acuta* Greg.
Cleve, Syn. II, p. 128.
A. S. Atl., pl. 26, fig. 25 (not very typical).
A single specimen in core 267.
*Amphora crassa* Greg.
Cleve Syn. II, p. 109.
A. S. Atl. pl. 39, fig. 30.

This form corresponds exactly with the figure in A. S. Atl. (mentioned by Cleve as being typical) although its structure (smooth costae) points to *Amphora egregia*.

A single specimen in core 227.
*Amphora egregia* (Ehr.) A. Schm.
Cleve Syn. II, p. 110.
A. S. Atl. pl. 28, fig. 13, 14.
Peragallo 1897, pl. 46, fig. 12.
A single specimen in core 267.
*Amphora proteus* Greg.
Cleve Syn. II, p. 103.
A. S. Atl., pl. 27, fig. 3.
A few individuals in core 267.
*Amphora spectabilis* Greg.
Cleve Syn. II, p. 132.
Leuduger-Fortmorel 1879, pl. 1, fig. 11.
Peragallo, 1897 pl. 48, fig. 8.
A few specimens in core 267.

**Asterolampra** Ehr.

*Asterolampra marylandica* Ehr.
A. S. Atl., pl. 137, fig. 19, 20
Hustedt 1927 I, p. 485.
Rather rare in cores 227, 233, 235.

**Asteromphalus** Ehr.

There is a marked difference in the distribution of *Asteromphalus*-species occuring in the Atlantic cores, as compared with the Pacific sediments. While 2 species were dominant in the latter sediments: *A. elegans* and *A. hiltonianus*, these species are only relatively rare in the Atlantic cores, while *Asteromphalus arachne* is decidedly the leading species of the genus in this area. Altogether the genus *Asteromphalus* has more representatives in the

Atlantic than in the Pacific cores, the forms belonging unfortunately to rather poorly studied, badly defined »difficult» species. This genus is in urgent need of a modern monographer. I mentioned in my list only such species which could be determined ± reliably.

*Asteromphalus arachne* (Grev.) Ralfs.

HUSTEDT 1927, I, p. 493.

Rather common in a series of cores, although not widely distributed in the area. Very constant with regard to size and structure.

Localities: cores 227, 233, 234, 235, 238.

*Asteromphalus beaumontii* Ehr.

RATTRAY 1890, p. 210.

A. S. Atl. pl. 38, fig. 8.

MANN 1937, p. 24, pl. 2, fig, 2.

Icon nostr. pl. I, fig. 8.

There is still some confusion with regard to this species. Some authors as, e. g. HUSTEDT (1927, p. 496), connect it with *Asteromphalus heptactis* and consider *Asteromphalus beaumontii* as dwarf specimens of the former species. Others, like MANN (l. c.) look upon it as a distinct species. I cannot take part in the discussion, as I have only seen 2 valves in the Atlantic cores, identical with fig. 8 in A. SCHMIDTs Atlas (l. c.). Comparing these specimens with *Asteromphalus heptactis* (also present in Atlantic cores) I consider the characteristic short rays as a good specific character and think it better to support MANNs views until a closer investigation of the group has been made.

The diameter of my specimens was 40 to 42 $\mu$ and their areolation was very coarse (5 areolae in 10 $\mu$).

Locality: core 234.

*Asteromphalus cleveanus* Grun.

RATTRAY 1890, p. 214.

A. S. Atl. pl. 38, fig. 13, 14.

Judging by the scanty mentions in literature this species seems to be very rare; even in the slides (CLEVE & MÖLLER, Diatoms, said to contain this species) I could not find a single valve. Through the kindness of Mr. Å. BERG, Uppsala, I had access to CLEVES original material and found 2 specimens identical with my individuals.

Very rare in 2 levels of core 238.

*Asteromphalus elegans* Grev.

RATTRAY 1890, p. 212.

A. S. Atl., pl. 38, fig. 1, 2.

In comparison with the finds in the Pacific cores this form is rare and has a more restricted distribution in the Atlantic. The specimens never reach the size of the Pacific individuals, the latter having a very considerable average size and attaining maximum diameters up to 186 $\mu$ while the maximum size of the Atlantic specimens never exceeded 70 $\mu$ in diameter.

Localities: cores 233, 234, 235, 238 — single specimens.

*Asteromphalus heptactis* (Breb.) Ralfs.

A. S. Atl., pl. 38, fig. 5, 6.

RATTRAY 1890, p. 216.

HUSTEDT 1927, I, p. 494.

Typical specimens were rather rare; they were found in cores 233/32, 235/440, 238/183 and 238/1182.

*Asteromphalus hiltonianus* (Grev.) Ralfs.

GREVILLE 1860, p. 117, pl. 4, fig. 15.

RATTRAY 1890, p. 213.

Rather rare in the area, mainly in core 238. The specimens were usually small and not typical.

Localities: cores 238/308, 238/617, 238/982, 235/440.

*Asteromphalus roperianus* Ralfs.

GREVILLE 1860, p. 120, pl. 4, fig. 14.

A. S. Atl., pl. 38, fig. 15.

RATTRAY 1890, p. 209.

Not frequent in cores 234, 233, 235 and 238.

*Asteromphalus shadboltianus* (Grev.) Ralfs.

GREVILLE 1860, p. 121, pl. 4, fig. 19.

A. S. Atl. pl. 38, fig. 17.

RATTRAY 1890, p. 208.

DE TONI 1891, p. 1411.

Icon nostr. pl. I, fig. 7.

DE TONI (l. c.) mentions this characteristic species from 2 localities only: Indian Ocean (deep-sea dredging from 2 200 fathoms, Captain

PULLEN) and Mejillones (Bolivia, fossil). In the Atlantic sediments the species was found in several cores, although never frequently.

Localities: cores 227, 233, 234, 235, 238.

### **Bacteriastrum** Shadb.

Many fragments of *Bacteriastrum* species were met with in the Atlantic cores, most of them lying on the valve and with broken seta, so that reliable determinations could be made in a few cases only.

*Bacteriastrum elegans* Pav.
HUSTEDT 1927 I, p. 621.
Locality: core 233/32.
*Bacteriastrum elongatum* Cl.
HUSTEDT 1927 I, p. 617.
Localities: cores 235/314, 238/308, 238/748.
*Bacteriastrum hyalinum* Laud.
HUSTEDT 1927 I, p. 615.
Locality: core 238/183.

### **Biddulphia** Gray

*Biddulphia pulchella* Gray.
HUSTEDT 1927 I, p. 832.
A few single specimens in cores 215, 227 and 238.

### **Campylodiscus** Ehr.

*Campylodiscus clypeus* Ehr.
HUSTEDT 1930, p. 448, fig. 873.
Localities: core 233/122, 233/762.
*Campylodiscus echeneis* Ehr.
HUSTEDT 1930, p. 449, fig. 875.
A very typical fragment in core 227/12.

### **Chaetoceros** Ehr.

As could be expected, only few remains of *Chaetoceros* species (and only of those having robust setae) reached the sea floor. Practically no resting spores were met with, which seems peculiar considering the often very thick and strongly silicified walls of these bodies.

*Chaetoceros coarctatus* Laud.
A. S. Atl. pl. 324, fig. 8—14.
HUSTEDT 1927 I, p. 655.

Usually the setae alone were present in the material; their shape and structure is so characteristic, that it is not difficult to distinguish them from *Ch. peruvianus*, a form with equally very robust setae.

Fairly frequent in some cores: 233, 234, 235, 238.

*Chaetoceros messanensis* Castr.
A. S. Atl. pl. 322, fig. 4, 7.
HUSTEDT 1927 I, p. 718.
Locality: core 234/11.

### **Cocconeis** Ehr.

*Cocconeis britannica* Naeg.
VAN HEURCK Syn. pl. 30, fig. 1,2.
HUSTEDT 1927 II, p. 333.
A single specimen in core 238.
*Cocconeis debesii* Hust.
HUSTEDT 1927 II, p. 344.
A few individuals in core 227/12.
*Cocconeis heteroidea* Hantzsch.
HUSTEDT 1927 II, p. 356.
Very rare in core 227: 227/12, 227/126.
*Cocconeis pinnata* Greg.
VAN HEURCK Syn. pl. 30, fig. 6,7.
PERAGALLO 1908, pl. 2, fig. 11—14.
A single specimen in core 215/13.
*Cocconeis scutellum* Ehr.
VAN HEURCK Syn. pl. 29, fig. 1,2.
Only a few specimens in cores 215 and 227.

### **Coscinodiscus** Ehr.

This genus is very poorly represented in the Atlantic cores. Only about half of the species met with in the Pacific sediments were found in the present material. Among the peculiarities of the *Coscinodiscus* flora of the Atlantic sediments I may note:

1. the total absence of *Coscinodiscus curvatulus*, *C. gigas*, *C. lanceolatus*, *C. lewisianus*, *C. paleaceus*, *C. plicatus*, *C. tabularis*, *C. vigilans* and some other species. Some of these species, well represented in the Pacifis cores, are under the strong suspicion of being extinct Pre-

Quaternary species. As no extinct species were met with in the Atlantic cores this may explain the lacking of the species mentioned above. A comparison of Table 2 of this paper with Table 2 in my survey of the Pacific cores (KOLBE 1954 p. 14) shows clearly the main divergencies in the distribution of diatoms in the sediment of the 2 oceans;

2. the relative dominance of *Coscinodiscus africanus* and the frequency of *C. crenulatus;*

3. the presence of the rare and probably endemic *Coscinodiscus reniformis* in some of the cores.

*Coscinodiscus africanus* Jan.

A. S. Atl., pl. 59, fig. 24.

HUSTEDT 1927 I, p. 428.

One of the leading species in the Atlantic sediments. Frequent and widely distributed in the area. Some of the specimens had central papillae not unlike *C. nodulifer.*

Localities: cores 215, 227, 233, 234, 235, 238 in most levels of the cores.

*Coscinodiscus anguste-lineatus* A. Schm.

A. S. Atl., pl. 59, fig. 34.

RATTRAY 1890, p. 26.

HUSTEDT 1927 I, p. 391.

A. CLEVE-EULER 1951, p. 61.

KOLBE 1954, p. 27 (here further literature cited).

The numerous specimens met with in the present material confirmed my opinion (KOLBE 1954) that this species is far from being definitely established. The main characters, in which the diagnoses differ are:

areolation: from 4—5 in 10 $\mu$ (HUSTEDT l.c.) to 10 in 10 $\mu$ (A. CLEVE-EULER l.c.).

margin: from »no marginal border» as in A. S. Atl. (l.c.) to »narrow hyaline border» (RATTRAY and HUSTEDT).

processes: from »no processes» (A. SCHMIDT, RATTRAY) to »up to 4 larger processes» (HUSTEDT, A. CLEVE).

The specimens from Atlantic (and Pacific) sediments showed neither hyaline borders nor processes and had a very constant and uniform areolation of 10 areolae in 10 $\mu$. The areolation was of the *Coscinodiscus lineatus*-type, though much finer and could not have been mistaken for *Coscinodiscus excentricus* with straight rows af areolae, as suspected by HUSTEDT (l.c.).

As all specimens from the Atlantic cores strictly agree with the cited figure in A. S. Atl. and as A. SCHMIDT is the author of the species, I consider my specimens belonging to the genuine *Coscinodiscus anguste-lineatus* A. Schm. A critical revision of this species should be made.

Widely distributed in the Atlantic sediments, although never frequent: cores 215, 227, 233, 234, 235, 238, 267.

*Coscinodiscus argus* Ehr.

HUSTEDT 1927 I, p. 422.

Rare in cores 215, 235, 238; more or less frequent in core 234, especially in the level 193 cm.

*Coscinodiscus asteromphalus* Ehr.

HUSTEDT 1927 I, p. 452.

Very rare in cores 227/661, 235/440 and 238/692.

*Coscinodiscus concinnus* W. Sm.

HUSTEDT 1927 I, p. 441.

Very rare. Cores 235/245, 235/314, 235/440 and 238/1182.

*Coscinodiscus crenulatus* Grun.

HUSTEDT 1927, I, p. 411.

Usually small individuals. Mostly in core 238, where the species was rather common in many levels. Rare in cores 215, 227, 233, 234, 235.

*Coscinodiscus excentricus* Ehr.

PERAGALLO 1897, pl. 116, fig. 3.

HUSTEDT 1927 I, p. 388.

One of the most common forms in practically all diatomiferous sediments of the Atlantic cores. Many specimens could be suspected to be the valves of *Planktoniella sol;* the membraneous external zone sorrounding the valve of this genus is very delicate and easily dis-

solved, while the structure of the valve itself is identical with *Coscinodiscus excentricus*. The membranes were never found in the sediments, whereas it is more than probable that *Planktoniella* was present in the plankton of the Equatorial Atlantic.

One point might be important: I observed in my material 2 types of *Coscinodiscus excentricus*. One type had a distinct border which was always lacking in the other (usually somewhat smaller) type. It seemed to me that the 2 types were not connected by transitional forms. It may be possible that the valves of the borderless type belonged to *Planktoniella*.

Besides the typical *Coscinodiscus excentricus* a much smaller form, described as var. *minor* (Ehr.) Perag. was frequently observed. Hustedt (l. c.) unites the variety with the typical form and so does Peragallo (l. c., p. 426).

Localities: cores 215, 223, 227, 228, 229, 233, 234, 235, 238.

*Coscinodiscus kurzii* Grun.

A. S. Atl., pl. 113, fig. 17.

Rattray 1890, p. 116.

Lohman 1941, p. 71, pl. 13, fig. 5.

*Coscinodiscus kurzii* can easily be mistaken for *Coscinodiscus obscurus* and I am not at all sure whether the two forms should not be united; Lohmans (l. c.) excellent photomicrogram could easily represent *C. obscurus*. It stands — taxonomically speaking — between *C. obscurus* and *C. argus* (sensu Hustedt 1927 I, p. 422). *Coscinodiscus kurzii* has in common with *C. obscurus* the presence of interstitial loculi and with *C. argus* — the different size of the areolae which very distinctly increase in magnitude towards the border. Only a few typical specimens could be determined and even these with some hesitation.

Very rare: cores 223, 235, 238.

*Coscinodiscus kützingii* A. Schm.

A. S. Atl., pl. 57, fig. 17, 18.

Rattray 1890, p. 33.

Hustedt 1927 I, p. 398.

Only a single specimen observed in the deepest level of core 233.

*Coscinodiscus lineatus* Ehr.

Rattray 1890, p. 24.

Hustedt 1927 I, p. 392.

This species is one of the most frequent and widespread forms in the Atlantic sediments, although not quite as common as *Coscinodiscus excentricus*. Present in most diatom-bearing levels of the cores.

Localities: cores 215, 223, 227, 229, 233, 234, 235, 238.

*Coscinodiscus lineatus* var. *ellipticus* Kolb.

Kolbe 1954, p. 32, pl. 2, fig. 15.

Very rare: only 2 specimens found in cores 227 and 238.

*Coscinodiscus nodulifer* A. Schm.

Hustedt 1927 I, p. 426.

Kolbe 1954, p. 33, pl. IV, Fig. 35—37.

Although this species is one of the common diatoms in the present material, it never reaches the development, size and dominance as compared with the Pacific cores. In both oceans it is the form with the widest distribution in the respective deep-sea cores. Nevertheless — in spite of its wide distribution in the Atlantic cores — *C. nodulifer* is rather rare in numbers, much rarer than, for instance, *C. excentricus* or *Nitzschia marina*. While in most of the Pacific sediments the frequency of *C. nodulifer* was always high and in some levels led to an absolute dominance over the rest of the species, this was never the case in the Atlantic cores.

The size of *C. nodulifer* was on an average small to medium in the Atlantic, ranging from 20 to 50 or 60 $\mu$ and reaching in a few rare cases 100 to 125 $\mu$ in diameter. While in the Pacific an average size of about 40 $\mu$ was also the most frequent, large sizes were very usual and in some sediments even predominant. The largest individuals in the Pacific measured over 200 $\mu$ and were not very rare; in the Atlantic a valve of 128 $\mu$ could be measured only once.

A very distinct rhythmical size variation of *C. nodulifer* could be stated in the Pacific (KOLBE 1954, p. 3 and 10); no trace of such variation could be observed in the Atlantic.

Widely distributed throughout the Atlantic cores, although never in great numbers.

*Coscinodiscus obscurus* A. Schm.

A. S. Atl., pl. 61, fig. 16.

HUSTEDT 1927 I, p. 418.

Very rare and only in the cores 233, 234 and 235.

*Coscinodiscus oculus iridis* Ehr.

A. S. Atl., pl. 63, fig. 6.

RATTRAY 1890, p. 111.

HUSTEDT 1927 I, p. 454.

A single specimen observed in core 215.

*Coscinodiscus radiatus* Ehr.

A. S. Atl., pl. 61, fig. 1—6, 9—10.

PERAGALLO 1897, pl. 117, fig. 3.

HUSTEDT 1927 I, p. 420.

Found in moderate numbers in cores 215, 223, 227, 233, 234, 235 and rather frequently in core 238.

*Coscinodiscus reniformis* Castr.

CASTRACANE 1886, p. 160, pl. 12, fig. 12.

A. S. Atl. pl. 140, fig. 7

RATTRAY 1890, p. 100.

HEIDEN & KOLBE 1927, p. 476.

MILLS 1933, p. 500.

Icon nostr., pl. I, fig. 4.

A figure of the species was listed and figured by JANISCH under the name of *Stoschia admirabilis* in a manuscript treating the Diatoms of the »Gazelle» Expedition. As this manuscript was never published, that name ought to be considered as a nomen nudum. CASTRACANE (l. c.) gave a diagnosis and a figure of the form under the name of *Coscinodiscus reniformis* which name is considered as valid by both RATTRAY and MILLS (l. c.)

This very large and conspicuous form appears to be very rare and its geographic area is an interesting problem. According to previous literature only a few localities could be established:

JANISCH — no printed report, but VAN HEURCK (1898, p. 537) cites from a letter of JANISCH: »Numerous examples of this interesting form have been found on the West Coast of Africa»;

CASTRACANE (l. c.) — true to his unfortunate custom does not state a locality and mentions the finds only as »different and widely separated»;

HEIDEN & KOLBE (l. c.) found the form at a point: lat. 0°.27′ N and long. 17° W.

In the present material C. reniformis was present in 3 cores situated as follows:

core 233 — lat. 7°.13′ N and long. 22°.38′ W
core 234 — lat. 5°.45′ N and long. 21°.43′ W
core 238 — lat. 0°.07′ S and long. 18°.12′ W

If we disregard the rather vague statement by CASTRACANE, the geographic position of the known localities cover a very restricted range: it is a ± narrow strip roughly parallel to a part of the West Coast of Africa.

In the present material the form was found in a few scattered fragments in the cores 233, 234 and 238. Only 2 undamaged valves were observed.

### **Cyclotella** Ktz.

*Cyclotella striata* (Ktz.) Grun.

HUSTEDT 1927 I, p. 344.

Not frequent in cores 233, 234, 235 and 238.

*Cyclotella stylorum* Brightw.

HUSTEDT 1927 I, p. 348.

More frequent than the foregoing species.

Localities: cores 223, 234, 235 and 238.

Both *C. striata* and *C. stylorum* were represented in small individuals only, the specific difference between the two forms being often very vague.

### **Dimerogramma** Ralfs.

The two species representing the benthonic genus *Dimerogramma* were observed at one station only, off the island of St. Thomé.

*Dimerogramma marinum* (Greg.) Ralfs.

PERAGALLO 1897, pl. 82, fig. 10, 11.

HUSTEDT 1927 II, p. 119.
Locality: core 267/6.
*Dimerogramma opulens* Mann.
MANN 1925, p. 74, pl. 15, fig. 6, 7.
Only one specimen in core 267/6.

**Diploneis** Ehr.

*Diploneis adonis* (Br.) Cl.
HUSTEDT 1927 II, p. 613.
Locality: core 215/13.
*Diploneis bombus* Ehr.
HUSTEDT 1927 II, p. 704.
Locality: core 227/126.
*Diploneis crabro* Ehr.
HUSTEDT 1927 II, p. 617.
Locality: core 267/6.
*Diploneis fusca* (Greg.) Cl.
HUSTEDT 1927 II, p. 654.
Locality: core 227/661.
*Diploneis nitescens* (Greg.) Cl.
HUSTEDT 1927 II, p. 640.
Locality: core 215/13.
*Diploneis weissflogii* (A. Schm.) Cl.
A. S. Atl. pl. 12, fig. 26—32.
PERAGALLO 1897, pl. 19, fig. 11.
HUSTEDT 1927 II, p. 703.
Localities: cores 233/32, 235/38, 238/308, 238/617.

**Ethmodiscus** Castr.

*Ethmodiscus rex* (Wall.) Hendey.
A. S. Atl., pl. 114, fig. 7.
HENDEY 1953, p. 49, pl. 1 and 2.

This species was dealt with monographically by HENDEY (l. c.), its nomenclature and geographic range were summarized carefully and excellent photomicrograms were provided.

The area of *Ethmodiscus rex* presents an interesting problem. HENDEY (l. c., p. 36) writes: »The geographic range of *Ethmodiscus rex* is not yet fully known, but it is likely to be more widespread than was at first thought» I not only fully agree with this statement, but believe that further investigations will show that it is one of the most common diatoms in the sediments of the equatorial seas. MANN (1907) and HENDEY (l. c.) observed »*Ethmodiscus-beds*» consisting mainly of broken mantles and valves belonging to this species. To HENDEYS table of localities (l. c., p. 58) I could add a long list of localities in the Atlantic; almost all of the Atlantic sediments investigated contained fair to large numbers of *Ethmodiscus* fragments and in several levels of some cores *Ethmodiscus rex* was by far the predominant species. This applies especially to the cores (and levels) 234/193 (maximum dominance), 230/99, 238/842, 238/882, 235/107, 235/314, 233/122 and 230/99. The rest of the localities (where the species was ± common but not predominant) is indicated below. In most cases only mantle fragments of *C. rex* were met with, while valve fragments were much rarer. HENDEY (l. c., p. 55) points out correctly: »The identification rests upon fragments of the central portion of the valve . . .» and only such localities were listed where such fragments could be observed. Very probably these localities form but a small part of the area of *Ethmodiscus rex*.

Localities: cores 215, 227, 228, 229, 230, 232, 233, 234, 235, 238.

No other species of the genus Ethmodiscus (at any rate no valve belonging to another *Ethmodiscus*-species) was found in the Atlantic sediments.

**»Fragments»**

CASTRACANE 1886, pl. 14, fig. 4, 4 a, 4 c.
Icon nostr., pl. I, fig. 9, 10, 11.

Fragments belonging undoubtedly to centric plankton forms (probably to their mantles) were met with in almost every sample of the present material. Three types could be distinguished easily and were observed by CASTRACANE too:

type 1: fragments with distant parallel rows of areolae or dots. They belonged very probably to mantles of *Coscinodiscus rex* and were identical with HENDEYS (l. c.

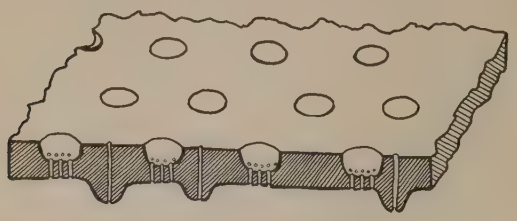

Fig. 5. "*Fragments*", type 3, hypothetical cross-section of membrane.

pl. 1, fig. 2) and CASTRACANES figures (l. c. fig. 4 a);

type 2: fragments with similar but very much finer structure than type 1 (CASTRACANE l. c., fig. 4 a);

type 3. fragments with parallel rows of areolae or dots crossed by irregular lines formed by larger areolae (CASTRACANE l. c., fig. 4, Icon nostr. pl. I, fig. 9—11). The nature of these »larger areolae» was studied under high power. At high focus (when focussed on the »normal areolae») they appeared as dark dots, larger than the »normal areolae» (pl. I, fig. 10) while at low focus (when the »normal areolae» are out of focus) they presented themselves as small and very bright puncta (pl. I, fig. 11). They show an opposite optical behaviour to the »normal areolae», which are light at high focus and dark at low focus. This behaviour is well known in optics and was already recommended by BRUN (1893, p. 139) and more recently by HUSTEDT as a simple optical test for the study of diatom membranes.

In the present case it proves without doubt that the »normal areolae» are thinnings of the silicified cell membrane, i. e. regular open chambers[1]) or poroids, while the »larger areolae» are nipple-like thickenings (may be mucous pores) of the membrane. Careful focussing shows that the chambers and thickenings are situated on the opposite surfaces of the membrane (see fig. 5 which represents a theoretical cross-section of the cell membrane).

[1]) Probably provided with sieve membranes (KOLBE 1951, p. 636), invisible under the light microscope.

Fragments of type 1 were by far the most common; type 2 was less common and type 3 relatively rare. Investigations of oceanic plankton might help to identify these important elements of the deep-sea sediments. Localities:

type 1 — cores 215, 227, 228, 229, 230, 232, 233, 234, 235, 238;

type 2 — cores 215, 223, 227, 233, 234, 235, 238

type 3 — cores 215, 227, 235, 238.

### **Grammatophora** Ehr.

*Grammatophora marina* var. *tropica* (Ktz.) Grun.

PERAGALLO 1897, pl. 87, fig. 4, 5.

HUSTEDT 1927 II, p. 44.

A single valve in core 215/13.

*Grammatophora oceanica* (Ehr.) Grun.

HUSTEDT 1927 II, p. 45.

A few specimens in core 267/6.

*Grammatophora oceanica* var. *maculata* (W. Sm.) Grun.

HUSTEDT 1927 II, p. 47.

A single valve in core 227/525.

*Grammatophora serpentina* (Ralfs.) Ehr.

HUSTEDT 1927 II p. 49.

A few valves in cores 215 and 227.

*Grammatophora undulata* Ehr.

HUSTEDT 1927 II, p. 48.

A few valves in cores 215, 227, 267.

### **Hemidiscus** Wall.

*Hemidiscus cuneiformis* Wall.

HUSTEDT 1927 I, p. 904.

This species is one of the most widely spread diatoms of the area investigated, although not so frequent as in the Pacific sediments. The individuals were rather small on the average and giant specimens (KOLBE 1954, p. 13) were never met with in Atlantic sediments. The outline of the valve was subject to similar variation as those recorded in the Pacific.

Localities: cores 215, 227, 230, 232, 233, 234, 235, 238.

*Hemidiscus rotundus* Jan.

A. S. Atl., pl. 437, fig. 10.

HUSTEDT (in A. S. Atl., l. c.) points out that the areolation of this form is much coarser and not so close as in the case of *Hemidiscus cuneiformis*. The looseness of the areolation tends to form an irregular central space which was observed in my specimens and is seen in some of HUSTEDTs figures on plates 437 and 438 (A. S. Atl.).

Very rare: a few scattered specimens in core 238/942.

### »Liostephania»

Liostephanias, those curious »natural artefacts» (Payne 1922) were much rarer in the Atlantic cores than in the Pacific ones. Plate I fig. 3 represents one of the few Liostephanias met with in the present material.

### **Liriogramma** Kolb.

The genus *Liriogramma* (KOLBE 1954) was represented in the Atlantic by a form easily distinguished from *Liriogramma petterssonii* by its oviform outline.

*Liriogramma hustedtii* nov. sp.

Icon nostr., fig. 6 and pl. II, fig. 21.

Valve small, oviform, length 24—26 $\mu$, breadth 10—12 $\mu$, areolae 10 in 10 $\mu$, central figure consisting of 6 irregular rays nearer to the broad end of the valve. Very rare.

This peculiar little form was observed in core 238 only (238/255, 238/308, 238/692); I found it in a material of the »Gauss» Expedition — curiously enough at about the same latitude of the Atlantic. In looking over some slides of the Pacific cores collected by the Swedish Deep-Sea Expedition, I observed the species in 2 localities (58/641 and 38/140) from the Pacific. The form is easily overlooked on account of its small size.

Fig. 6. *Liriogramma hustedtii* nov. sp.

Localities known so far:

Atlantic — lat. 0° 7′ N. long. 18° 19′ E (»Albatross»).
lat. 0° 8′ N, long. 16° 19′ E (»Gauss»)

Pacific — lat. 6° 44′ N, long. 129° 28′ W (»Albatross»)
lat. 2° 52′ S, long. 89° 5′ W (»Albatross»)

Dedicated to the diatomologist Dr. F. Hustedt.

### **Melosira** Ag.

*Melosira sulcata* (Ehr.) Ktz.

HUSTEDT 1927 I, p. 276.

Rather rare in the Atlantic cores.

Localities: 215, 223, 227, 238, 255.

### **Navicula** Ehr.

A few single valves of this principally benthonic genus were observed in the Atlantic sediments.

*Navicula forcipata* var. *suborbicularis* Gr.

VAN HEURCK 1880, pl. 10, fig. 5.

CLEVE 1894 II, p. 65.

Locality: core 215/13.

*Navicula hennedyi* W. Sm.

PERAGALLO 1897, pl. 25, fig. 2.

Locality: core 215/13.

*Navicula lyra* var.(?) *constricta* H. Per.

PERAGALLO 1897, pl. 28, fig. 3.

Locality: core 267/7.

*Navicula lyra* var. *recta* Grev.

A. S. Atl., pl. 2, fig. 18.

CLEVE 1894 II, p. 64.

PERAGALLO 1897, pl. 22, fig. 7.
Locality: core 227/661.
*Navicula irrorata* Grev.
A. S. Atl., pl. 2, fig. 22.
CLEVE 1894 II, p. 56.
Locality: core 267/6.

**Nitzschia** Hass.

*Nitzschia aequatorialis* Heid.
HEIDEN & KOLBE 1927 p. 665, pl. 7, fig. 149.
Icon nostr. pl. II, fig. 24.

*Nitzschia aequatorialis* is characterized by its slender form and the rather coarse striation consisting of almost rectangular puncta. The dimensions in the present material varied between:
length: 91—105 $\mu$.
breadth: 6.5—10 $\mu$.
striae, longitudinal: 10—12 in 10 $\mu$.
striae, transverse: 14—15 in 10 $\mu$.
carinal dots: 7—8 in 10 $\mu$.

This characteristic form was observed by HEIDEN (l. c.) in two samples from the Equatorial Atlantic (lat. 8° 5′ S, long. 13° 49′ W). In the material collected by the Swedish Deep-Sea Expedition several specimens were observed in about the same area of the Atlantic:
core 233/32 — lat. 7° 13′ N, long. 22° 38′ W.
core 235/440 — lat. 3° 12′ N, long. 20° 28′ W
core 238/748 — lat. 0° 7′ S, long. 18° 12′ W.

The form seems to be very rare.

*Nitzschia interrupta* Heid.
HEIDEN & KOLBE 1927, p. 665, pl. 7, fig. 150.
Icon nostr. pl. II, fig. 25, 26, 27.

*Nitzschia interrupta* is a rather small but very typical form, which seems to have been overlooked: I find no mention of it so far, although — according to my finds in the Atlantic — it appears to be neither rare nor restricted to a small area.

The 2 inframarginal lines mentioned and figured by HEIDEN are formed by 2 interruptions of the transapical striae, as demonstrated in our figure 27 on Plate II.

Localities: cores 227, 233, 234, 235, 238 (in many levels).

*Nitzschia kolaczeckii* Grun.
Synonyms: *Nitzschia lanceolata* var. WALLICH 1860, p. 48, pl. 2, fig. 20.
*Nitzschia wallichiana* PETIT 1889, p. 127, pl. 10, fig. 9.
GRUNOW 1877, p. 165, pl. 94, fig. 10.
A. S. Atl. pl. 349, fig. 38, 39.
Icon nostr. pl. II, fig. 22, 23.

*Nitzschia kolaczeckii* is a conspicuous representative of the genus, well characterized by its peculiar striation: the puncta alternate very regularly in each of two proximate striae and present at a certain focus a typical oblique *Pleurosigma*-like striation, very uncommon, if not unique in the section of *Nitzschiae lanceolatae*.

The species was first described and (rather poorly) figured by WALLICH (l. c.) as a variety of *Nitzschia lanceolata* W. Sm.; WALLICH observed and pointed out the typical *Pleurosigma*-like structure. PETIT (l. c.) emended WALLICHs diagnosis and named the species *Nitzschia wallichiana*, evidently not knowing that GRUNOW (l. c.) gave a very good description and an excellent figure of the species under the present name. The original spelling of the name was *Nitzschia kolaizeckii*, which GRUNOW changed later (CLEVE & GRUNOW 1880 p. 95) into *N. kolaczeckii*. I consider this to be the correct name and the spelling in A. S. Atl. (l. c.: *N. kolascecki*) as erroneous.

Our photomicrogram Pl. II, fig. 23 shows two valves of the same frustule taken at a different focus thus presenting the real and the virtual aspect of the striation.

The dimensions of the specimens met with in the present material lie within the limits given by the descriptions and were usually: length 79—91 $\mu$, breadth 9—11 $\mu$, striae 15—17 in 10 $\mu$, carinal dots 8 in 10 $\mu$.

Localities: very rare in cores 215/13, 238/8, 238/183 and 238/792.

*Nitzschia marginulata* Grun.

PERAGALLO 1897, p. 270, pl. 70, fig. 14, 15.

Locality: core 267/6.

*Nitzschia marina* Grun.

CLEVE & GRUNOW 1880, p. 70.

VAN HEURCK 1880, pl. 57, fig. 26, 27.

LOHMAN 1941, pl. 17, fig. 11.

Icon nostr. pl. II, fig. 28, 29.

*Nitzschia marina* is undoubtedly the most common diatom in the Atlantic cores. It has also the widest distribution in the area. Extremely long individuals (up to 200 $\mu$ and more) occur rather frequently.

A specimen was lying in a favourable position and showed distinctly the carinal dots (cfr. our fig. 29 on Pl. II). I do not think that the taxonomic position of the present form — viz. in the genus *Nitzschia* — can be doubted any longer. (cfr. KOLBE 1954, p. 40)

Localities: frequent in almost all of the Atlantic cores.

*Nitzschia panduriformis* Greg.

PERAGALLO 1897 p. 268, pl. 70, fig. 3—5.

Locality: core 238/183.

*Nitzschia panduriformis* var. *minor* Grun. (perhaps but a small individual of the former species).

PERAGALLO 1897, p. 269, pl. 70, fig. 6.

Locality: core 227/525.

*Nitzschia socialis* var. *massiliensis* Grun.

CLEVE & GRUNOW 1886, p. 85.

PERAGALLO 1897, pl. 72, fig. 10.

Locality: core 227/525.

### Opephora P. Petit

*Opephora marina* (Greg.) Pet.

HUSTEDT 1927 II, p. 136.

Locality: core 227/12.

*Opephora swartzii* (Grun.) Perag.

GRUNOW 1863, p. 143, pl. 14, fig. 7.

PERAGALLO 1897, p. 327, pl. 83, fig. 1, 2.

Icon nostr. pl. II, fig. 18, 19.

This form was described and figured by GRUNOW (l. c.) as *Fragilaria swartzii* (not *schwartzii*, as spelt by PERAGALLO and others) and transferred to the genus *Opephora* by PERAGALLO. The outline of *Opephora swartzii* is practically linear in GRUNOWS figure and was always almost linear in the specimens of the present material. It differs from *Opephora pacifica* by its size, its more slender form and its evidently coarser costae. The dimensions of the few individuals met with in core 227 were: length 84—90 $\mu$, breadth 10—11 $\mu$, costae 4 in 10 $\mu$, and agreed with GRUNOWS description. The specimens figured by PERAGALLO (l. c.) seem to me not typical on account of their broad cuneiform outline.

Locality: a few valves in core 227/523.

### Plagiogramma Grev.

*Plagiogramma pulchellum* var. *pygmaeum* (Grev.) Perag.

HUSTEDT 1927 II, p. 108.

Very rare in core 227/525.

### Podosira Ehr.

*Podosira hormoides* (Mont.) Ktz.

CLEVE & GRUNOW 1879, p. 118.

GRUNOW 1884, p. 40, pl. 5, fig. 32.

VAN HEURCK, 1880, pl. 84, fig. 3.

HUSTEDT 1927 I, p. 285.

Icon nostr. pl. I, fig. 1, 2.

The specimens met with in the Atlantic sediments did not agree in all details with the descriptions and figures in modern and older literature. The density of areolation was not always constant: 14 areolae in 10 $\mu$ was the usual density, but in rare cases a denser (18 in 10 $\mu$) or coarser (10 in 10 $\mu$) areolation could be observed. The diameter was well within the limits given by HUSTEDT (l. c.), but the scattered dots were not arranged along the lines separating the sectors, but were distributed irregularly all over the valve (cfr. our figure). A row of small but very evident apiculi, about 6 $\mu$ distant from each other, was always present; I could find no mention of these apiculi in the descriptions of this form.

A larger asymmetrical process was observed once or twice.

Localities: cores 227, 230, 233, 234, 235, 238.

### Pseudoeunotia Grun.

*Pseudoeunotia doliolus* (Wall.) Grun.

HUSTEDT 1927 II, p. 259.

One of the most common forms in the Atlantic sediments although seldom found in great numbers.

Localities: present in all diatomiferous cores and in most of their levels.

### Raphoneis Ehr.

*Raphoneis amphiceros* Ehr.

VAN HEURCK 1880, pl. 116, fig. 17 (var. *minor*).

HUSTEDT 1927 II, p. 174.

Locality: core 227/126.

*Raphoneis belgica* Grun.

HUSTEDT 1927 II, p. 176.

Locality: core 215/13.

### Rhabdonema Ktz.

*Rhabdonema adriaticum* Ktz.

HUSTEDT 1927 II, p. 23.

Locality: core 227/661.

*Rhabdonema arcuatum* Ktz.

HUSTEDT 1927 II, p. 20.

Locality: core 227/525.

### Rhizosolenia Ehr.

Only relatively few representatives of this widespread and common planctonic genus were met with and could be identified with certainty. All copulae were completely dissolved and the identification was entirely based on the calyptrae which often showed signs of corrosion. In comparison with the Pacific cores (KOLBE 1954) the Atlantic cores are, however, definitely richer in *Rhizosoleniae*.

*Rhizosolenia alata* Brightw.

HUSTEDT 1927 I, p. 600.

Localities: cores 227/126, 233/32.

*Rhizosolenia bergonii* Perag.

HUSTEDT 1927 I, p. 575.

Localities: fairly frequent in cores 234, 235, frequent in core 238.

*Rhizosolenia calcar avis* Schulze.

HUSTEDT 1927 I, p. 592.

Localities: very rare in cores 235 and 238.

*Rhizosolenia hebetata* (Bail.) Gran. (mostly f. *hiemalis* Gran.)

HUSTEDT 1927 I, p. 590.

Localities: rare in core 215, rather frequent in cores 227 and 233, very frequent in core 238.

*Rhizosolenia imbricata* var. *shrubsolei* (Cl.) Schröd.

HUSTEDT 1927 I, p. 584.

Very rare in core 238.

*Rhizosolenia styliformis* Brightw.

HUSTEDT 1927 I, p. 584.

Localities: frequent in cores 233, 235, 238.

*Rhizosolenia styliformis* var. *longispina* Hust.

HUSTEDT 1927 I, p. 584.

Localities: rare in core 238/8, very frequent in core 238/692.

### Roperia Grun.

*Roperia tesselata* (Rop.) Grun.

HUSTEDT 1927 I, p. 523.

One of the most common and widespread species in some Atlantic cores.

Localities: cores 227, 233, 234, 235, 238, 257.

*Roperia tesselata* var. *coscinodiscoidea* (Mann) nov. comb.

Synonym: *Actinocyclus coscinodiscoides* MANN 1937, p. 19, pl. 1, fig. 5.

Icon nostr. pl. I, fig. 6.

In my survey of the diatoms from Pacific cores (KOLBE 1954) I presumed that MANNS *Actinocyclus coscinodiscoides* is probably identical with *Roperia tesselata*. The structure of MANNS species shows no distinct radial areolation, so typical for the representatives of the genus *Actinocyclus;* the ocellus of his form (in the specimens observed by me) had the same

dull lustre typical for *Roperia*.[1]) The areolae are largest at the centre and gradually diminish in size towards the periphery and show a ± distinct fasciculation. This character is neither typical for *Actinocyclus*, nor for *Roperia*, but I had ample evidence of a more or less pronounced fasciculation in *Roperia tesselata* showing that this character is not a reliable one, in this special case, at least; some specimens showing structural transitions between the typical *Roperia tesselata* and var. *coscinodiscoidea* were observed in the present material. On the strength of these reasons I suggest including MANNs form (which was very constant in the Atlantic sediments) in the genus *Roperia* as a »good» variety: *Roperia tesselata* var. *coscinodiscoidea*.

The diameter of the Atlantic specimens varied between 36 and 40 $\mu$ while the areolation was very constant about 6—7 in 10 $\mu$ in the middle of the disc.

Localities: fairly frequent in cores 235 and 238.

*Roperia tesselata* var. *ovata* Mann.

MANN 1925, p. 143, pl. 31, fig. 3.

HEIDEN & KOLBE 1927, p. 507.

This characteristic variety was comparatively frequent in the Atlantic sediments. The crenulation of the margin at the broad end of the valve observed by MANN (l. c.) and KOLBE (1954 p. 45) was found to be a very constant character in the present material too. In one of the sediments (233/32) the variety was more frequent than the typical form.

Localities: cores 227, 233, 235, 238.

It should be noted that *Roperia tesselata* var. *elliptica* Kolb. (KOLBE 1954), of frequent occurence in the Pacific sediments, was never observed in the Atlantic cores.

### **Scoliopleura** Grun.

*Scoliopleura tumida* (Breb.) Rabh.

PERAGALLO 1897, p. 153, pl. 28, fig. 9, 10.

Locality: core 215/13.

### **Stictodiscus** Grev.

*Stictodiscus parallelus* f. *hexagona* (Castr.) nov. comb.

Synonym: *Stictodiscus hexagonus* CASTRACANE 1886, p. 122, pl. 17, fig. 14 and 17.

Icon nostr. pl. I, fig. 5.

HUSTEDT (in A. S. Atl. pl. 441—453) makes a new revision of the genus *Stictodiscus* and states the specific characters of its very variable species. According to HUSTEDTs definition and judging from CASTRACANEs figures (l. c.), his *Stictodiscus hexagonus* is very probably a hexagonal form of *Stictodiscus parallelus*. Some species of this genus are known to develop polygonal forms; some quadrangular forms of *Stictodiscus parallelus* are figured by HUSTEDT (A. S. Atl. pl. 453) from material from Leton Bank, Cap Verde Islands. It is interesting that the only specimen of *Stictodiscus parallelus* f. *hexagona* in the present material was observed in a core not very distant from HUSTEDTs locality.

A single valve in core 215/13.

### **Surirella** Turp.

*Surirella fastuosa* Ehr.

PERAGALLO 1897, p. 248, pl. 58, fig. 6, 7.

Very rare in core 227/525.

*Surirella fastuosa* var. *cuneata* A. Schm.

A. S. Atl. pl. 4, fig. 1, 2.

[1]) MANN describes the diffence between the ocelli of *Actinocyclus* and *Roperia* very explicitly: »... the true *Actinocyclus* pseudonodule is a double convex thickening of the siliceous cell wall, that is, a lens (not a mere circular blank space like the spot in *Roperia*.» MANNs statement as to the nature of the ocelli is not correct: the ocelli of both genera *Actinocyclus* and *Roperia* are not thickenings but thinnings of the cell membrane. A simple optical test proves it: at high focus the ocelli appear as ± bright spots, at low focus as darker ones. They have the same optical behaviour as the areolae. Thick valves accentuate the optical effect. Thus most of the coarse *Actinocyclus* species show it much better than the thin walled *Roperia* whose »pseudonodules» have therefore a rather dull lustre which probably led MANN to his erroneous conclusion.

The excellent electron micrograph by HELMCKE & KRIEGER (1953, pl. 28) reveals the true nature of the ocellus of *Actinocyclus* (and very probably also of *Roperia*): it is a mucous pore.

PERAGALLO 1897, p. 248, pl. 58, fig. 3, 4.

A single valve in core 238/882.

*Surirella fluminensis* Grun.

GRUNOW 1862, p. 43.

A. S. Atl., pl. 4, fig. 9; pl. 5, fig. 6.

PERAGALLO 1897, p. 249, pl. 60, fig. 1, 2.

Very rare in core 215/13.

### **Thalassionema** Grun.

*Thalassionema bacillaris* (Heid.) nov. comb.

Synonym: *Spinigera bacillaris* Heid. (HEIDEN & KOLBE 1927, p. 564, pl. 5, fig. 1).

HEIDEN (l. c.) established the genus *Spinigera* for some forms met with in the material of the »Gauss» Expedition, with the following characters: »Schalen an den Rändern mit einer Reihe Punkte, die je mit einem Stigma versehen sind. Vor den Schalenenden ein kleiner nach innen gerichteter Stachel.» The last character — the small process at the ends of the valves — is in common with the genus Thalassionema and cannot be considered as a generic character although it is true that in *Thalassionema* the processes are more developed than in HEIDENS specimens and protrude from the borders of the valves. These minute structures are, however, very difficult to see clearly, let alone to decide whether they belong to the one or the other type. The same applies to the other character of the genus — the very short marginal dots which are said to be provided with a stigma each according to HEIDENS definition. Even using the best objectives (apochromates) I was never able to discern a ± evident stigma as the marginal dots were usually extremely short and optically influenced by inner reflections and shadows making a reliable observation impossible. In short: in comparing HEIDENS original material with my slides from Atlantic and Pacific sediments I could not observe any actual difference between *Thalassionema* and HEIDENS *Spinigera*. »*Spinigera bacillaris*» Heid. is a large species, well characterized by its outline (which the other *Spinigera*-species are not) and even in this case I could not make out the stigmata mentioned by HEIDEN. I think that HEIDEN was the victim of a delusion caused by the complicated optical conditions of refraction and reflection of a curved siliceous margin of the valve and I do not believe it advisable to establish a genus on so vague a character.

I suggest therefore to draw in the genus *Spinigera* Heid. and to include its species in the genus *Thalassionema*.

Locality: very rare in core 235/374.

*Thalassionema nitzschioides* Grun.

VAN HEURCK 1880, pl. 43, fig. 6—12.

HUSTEDT 1927 II, p. 244.

HEIDEN & KOLBE 1927, p. 563, pl. 5, fig. 115—118.

*Thalassionema nitzschoides* belongs to the most common and widespread diatoms of the Atlantic cores. GRUNOW (VAN HEURCK l. c.) and HEIDEN (l. c.) described a number of »varieties», all of which could be observed in Atlantic and Pacific sediments. Very often several of them were crowded in a single field of vision. It is a parallel case to *Hemidiscus cuneiformis* (cfr. HUSTEDT 1927 and KOLBE 1954): the variability of both species is so great that it is not correct to consider their variations as varieties, as they probably do not even deserve the rank of formae. In the present material I did not list them separately, but included the observed formae: *javanica* Grun., *lanceolata* Grun., *gracilis* Heid., *inflata* Heid., and *parva* Heid., in the species. I may mention that in some cores f. *parva* and f. *inflata* were unusually frequent.

Localities: in almost all diatomiferous Atlantic sediments.

### **Thalassiosira** Cl.

*Thalassiosira decipiens* (Grun.) Jörg.

HUSTEDT 1927 I, p. 322.

Widely spread in the area but never in great numbers.

Localities: cores 215, 227, 233, 234, 235, 238.

**Thalassiothrix** Cl. & Grun.

*Thalassiothrix frauenfeldii* Grun.

Hustedt 1927 II, p. 247.

Curiously enough this form was observed in one single level (32 cm from top) of core 233 only; at this locality it was very frequent.

*Thalassiothrix longissima* Cl. & Grun.

Hustedt 1927 II, p. 247.

One of the very common forms of the area, but not as common as *Thalassionema*. Both *Thalassiothrix* and *Thalassionema* were met with mostly as fragments making a correct identification often rather difficult.

Localities: frequent in cores 233, 234, 235, 238.

**Trachyneis** Cl.

*Trachyneis aspera* var. *oblonga* (Bail.) Cl.

Cleve 1894 I, p. 198.

Peragallo 1897, pl. 29, fig. 13.

A single valve in core 227/126.

*Trachyneis aspera* var. *vulgaris* Cl.

Cleve 1894 I, p. 191.

Peragallo 1897, pl. 29, fig. 5.

Very rare. Cores 227/12 and 223/14.

**Triceratium** Ehr.

*Triceratium alternans* Ehr.

A. S. Atl. pl. 78, fig. 12.

Hustedt 1927 I, p. 826.

The rare specimens met with in the Atlantic cores did not fully agree with Hustedts description inasmuch as the »einige unregelmässige Furchen im mittleren Teil der Valva» were completely lacking; this might be a peculiarity of the small specimens of this form. It was in full agreement with fig. 12 in A. S. Atl. (l. c.).

Neither Hendey (1937) nor Lohman (1941) observed this widespread species in their materials.

Localities: cores 215, 223, 227, 267.

*Triceratium cinnamomeum* Grev.

Van Heurck 1880, pl. 126, fig. 1.

Not very frequent in cores 227, 233, 234, 235 and 238.

*Triceratium cinnamomeum* var. minor Grun.

Van Heurck 1880, pl. 126, fig. 2.

This little form is widely spread in the present material but never appears in great numbers. The regularity of its occurence in the area is, however, remarkable and therefore it is noteworthy that Hendey (1937) observed it in one of his samples only and Lohman (1941) does not mention it at all. It may be explained by its habitat: the form is probably restricted to warmer seas.

Localities: cores 215, 227, 233, 234, 235, 238.

## FRESHWATER SPECIES

Most of the freshwater diatoms met with in the Atlantic cores are common species of a worldwide distribution. As they are mostly well known I shall leave out citations of diagnoses and figures in most cases and only mention the localities. A few halophilous or mesohalobous forms are included in the list.

*Amphora ovalis* Ktz.

Localities: cores 234/351, 235/38, 235/374.

*Anomoeneis sphaerophora* (Ktz.) Pfitz.

Localities: cores 234/193, 235/38, 235/175.

*Anomoeoneis serians* var. *brachysira* (Breb.) Hust.

Locality: core 234/552.

*Cocconeis placentula* Ehr.

Locality: core 235/314.

*Cyclotella comta* (Ehr.) Ktz.

Localities: cores 235/374, 238/8, 246/12.

*Cyclotella kützingiana* Thw.

Localities: core 235/175.

*Cyclotella meneghiniana* Ktz.

Localities: cores 234/193, 238/8.

*Cyclotella ocellata* Pant.

Localities: cores 235/175, 235/245, 238/452, 238/792, 238/982.

*Cymbella affinis* Ktz.

Locality: core 235/314.

*Cymbella cistula* (Hempr.) Grun.

Localities: cores 227/661, 234/351.

*Cymbella grossepunctata* var. *obtusiuscula* O. Müll.

O. MUELLER, 1905, p. 154, pl. 1, fig. 13.

This characteristic form agrees fully with MUELLERS (l. c.) form from Nyassaland (Africa). A very similar, if not identical form was figured by HUSTEDT (1942, p. 98, fig. 181) under the name *Cymbella subalpina* Hust. His fig. 181 differs from the rest of the figures illustrating *Cymbella subalpina* (fig. 182—190) and it seems to me that the figure mentioned above might represent MUELLERS form.

Locality: core 227/864.

*Cymbella hebridica* (Greg.) Grun.

Locality: core 234/552.

*Cymbella helvetica* Ktz.

Localities: cores 227/126, 234/351.

*Cymbella incerta* Grun.

Locality: core 234/552.

*Cymbella turgida* (Greg.) Cl.

Localities: cores 227/525, 233/762, 234/193, 235/39.

*Diploneis elliptica* (Ktz.) Cl.

Locality: core 277/126.

*Epithemia argus* Ktz.

Localities: cores 227/661, 225/12, 234/11, 234/91, 235/38.

*Epithemia sorex* Ktz.

Localities: cores 223/14, 227/12, 234/91.

*Epithemia turgida* (Ehr.) Ktz.

Locality: core 227/864.

*Epithemia zebra* (Ehr.) Ktz.

Localities: cores 227/126, 227/661, 227/525, 235/314, 235/374, 238/175, 238/308.

*Epithemia zebra* var. *saxonica* (Ktz.) Grun.

Localities: cores 234/193, 234/552, 235/38.

*Eunotia didyma* Grun.

Locality: core 229/409. A single fragment of this tropical form was met with; I am indebted to Mr. Å. BERG for its identification.

*Eunotia praerupta* Ehr.

Localities: cores 234/552, 235/107.

*Eunotia tschirchiana* O. Müll.

The area of this form, as known up to the present, includes tropical and subtropical habitats only (tropical Asia and Africa, New Guinea, Florida) with one expection: Balkan (HUSTEDT). I am indebted to Mr. Å. BERG for the identification of this form.

Locality: core 235/440.

*Fragilaria construens* (Ehr.) Grun.

Locality: core 235/374.

*Frustulia rhomboides* var. *saxonica* (Rabh.) De Toni.

Locality: core 234/552.

*Gomphonema acuminatum* Ehr.

Localities: cores 234/193, 234/552, 235/175.

*Gomphonema gracile* Ehr.

Localities: cores 230/9, 235/374.

*Gyrosigma attenuatum* (Ktz.) Rabh.

Locality: core 227/126.

*Hantzschia amphioxys* (Ehr.) Grun.

Localities: cores 229/8, 229/409, 233/32, 238/183, 238/409.

*Mastogloia elliptica* Ag.

Locality: core 235/374.

*Mastogloia elliptica* var. *dansei* (Thw.) Grun.

Localities: cores 234/91, 235/374.

*Mastogloia smithii* Thw.

Localities 235/38, 238/792.

*Melosira ambigua* (Grun.) O. Müll.

Localities: cores 233/32, 233/762, 234/193, 235/175, 235/107, 235/245 (very frequent), 238 in many levels, often frequent, 246/12.

*Melosira granulata* (Ehr.) Ralfs including: f. *curvata*, Grun. and var. *valida* Hust.

This form deserves special attention. *Melosira granulata* is by far the most frequent freshwater diatom in the sediments of the Equatorial Atlantic. All diatomiferous cores of the area contained frustules, valves or short chains of *Melosira granulata*. Core levels, poor in diatoms contained about 10—50 valves per slide; in other levels the form was frequent to very frequent and in a few levels the species was predominant.

In 2 slides, *Melosira granulata* valves were actually counted. The following figures resulted:

Core 235/245 — — about 1,800 valves per cover (18×18 mm).

Core 235/374 — — about 3,700 valves per cover (18×18 mm).

In order to give a more concrete idea of the frequency figures of *Melosira granulata* in core 235/374 I may mention that at a medium magnification 5 valves (on an average) could be seen in every field of vision of about 600 $\mu$ in diameter.

*Melosira italica* (Ehr.) Ktz.
Localities: cores 234/193, 235/374.
*Navicula gastrum* Ehr.
Locality: core 227/525.
*Navicula gregaria* Donk.
Locality: core 238/692.
*Navicula mutica* Ktz.
Locality: core 227/12.
*Navicula oblonga* Ktz.
Localities: cores 227/661, 235/175, 235/38.
*Navicula peregrina* (Ehr.) Ktz.
Locality: core 234/11.
*Navicula perottetii* Grun.
Locality: core 227/12.
*Navicula pupula* Ktz.
Localities: cores 235/38, 235/314.
*Navicula radiosa* Ktz.
Locality: core 234/552.
*Navicula tuscula* (Ehr.) Grun.
Locality: core 238/8.
*Nitzschia amphibia* Grun.
Locality: core 267/6.
*Nitzschia denticula* Grun.
Locality: core 235/38.
*Pinnularia borealis* Ehr.
Locality: core 227/12.
*Pinnularia gibba* Ehr.
Localities: cores 234/193, 234/552.
*Pinnularia major* Ktz.
Localities: cores 234/552, 238/1182.
*Pinnularia microstauron* (Ehr.) Cl.
Localities: cores 234/552, 238/882.
*Pinnularia microstauron* var. *brebissonii* (Ktz.) Hust.
Localities: cores 234/193, 235/440.
*Pinnularia polyonca* (Breb.) O. Müll.
Locality: core 234/552.
*Pinnularia viridis* var. *intermedia* Cl.
Locality: core 255/12.
*Rhopalodia gibba* (Ehr.) O. Müll.
Localities: cores 230/9, 235/38.
*Rhopalodia gibberula* (Ehr.) O. Müll.
Locality: core 235/175.
*Rhopalodia gibberula* var. *protracta* Grun.
Locality: core 235/107.
*Stephanodiscus astraea* (Ehr.) Grun.
Localities: cores 227/12, 227/661, 233/264, 234/193, 235/38, 235/175, 235/314, 235/440, 238/8, 238/105, 238/512, 238/1408.
*Surirella biseriata* Breb.
Locality: core 235/440.
*Surirella robusta* Ehr.
Locality: core 238/308.
*Synedra capitata* Ehr.
Locality: core 234/552.
*Synedra ulna* (Nitzsch) Ehr.
Localities: cores 233/122, 234/552.
*Tabellaria fenestrata* (Lyngb.) Ktz.
Locality: core 234/552.
*Tabellaria flocculosa* (Roth) Ktz.
Locality: core 234/552.

## Appendix. Silicified epidermal cells

At the first examination of Atlantic cores containing freshwater diatoms I was struck by the presence of numerous peculiar bodies. The shape of these bodies was irregular though always typical, most of them resembling dumb-bells; they can be described as short silicified minute objects with broad ends and strongly constricted in the middle. In rarer cases two or three constrictions could be observed (see pl. II, fig. 15 and 16). Under the microscope they appear as $\pm$ transparent and refringent, mostly colourless objects (pl. II, fig. 14,15,17). Some of them were coloured light to dark brown (pl. II, fig. 12,13,16), the colour probably due to infiltration of iron or manganese compounds.

I have seen these objects more or less regularly in freshwater sediments treated with $H_2SO_4$ for diatom studies but only rarely and hitherto I have paid no special attention to them. Their frequency in most diatomiferous Atlantic

sediments called for further investigation. I could find no mention of them in works on sediments nor in palynological literature until I found them described and figured in works on the anatomy of plant epiderms.

In their investigations of the anatomy of epiderms, GROB (1896) and PRAT (1935) devoted chapters to the so-called »Kurzzellen» (GROB 1. c.) or »cellules courtes» (PRAT 1. c.) of *Gramineae* and *Cyperaceae*. According to the descriptions and the figures of the said authors, most of the bodies met with in the present sediments belong to the type named »Hantelzellen» (GROB) or »cellules en haltères» (PRAT, see my fig. 12, 13, 14 on pl. II), others to the so-called »cellules en bâtonnet» (see my fig. 15 and 16) or »cellules en croix» (rarely observed, not figured for the present paper). The »cellules courtes» are epidermal cells of *Gramineae* and *Cyperaceae* whose whole interior becomes silicified in the living plant; the resulting compact silica »casts» are obviously very resistant to corrosion after the death and the decay of the plant.

PRAT (1. c., p. 88) writes on this subject: »*Cellules courtes*. Une des particularités les plus frappantes des épidermes des Graminées est l'abondance des cellules incrustées de silice. Dans un épiderme adulte ces cellules sont mortes et remplies par un bloc de silice transparente, présentant seulement quelques granulations. Leur dimensions sont le plus souvent comprises entre 5 et 20 $\mu$ et leur examen requiert un grossissement de 500 à 1,000. Très réfringentes, elles sont faciles à distinguer au milieu des autres tissus et leur formes variées, mais parfaitement constantes dans chaque groupe, fournissent des charactères précieux pour distinguer les unités naturelles de la famille.»

It is a rather important question whether the bodies met with in the sediments can be indisputably identified with the siliceous epidermal cells treated above. The two types of objects are doubtless similar; besides two circumstances seem definitely to prove their identity:

1. The bodies in the sediments occur exclusively in such cores which are rich in freshwater diatoms, thus pointing to their continental origin.
2. In a few instances I could observe groups of »dumb-bell» cells in their organic connection, with traces of the cuticle still adhering. They were difficult to photograph since they were very rare and always in unfavourable positions. Pl. II, fig. 17 represents a group of three »dumb-bell» cells with some remains of the cuticle slightly detached from these cells and still showing their contours.

It appears that silicified epidermal cells might be of some use for the study of sediments as indicators of their non-marine origin. In sediments where conditions for the preservation of thin walled (freshwater) diatoms have been unfavourable, such bodies may still persist because of their high resistance to corrosion and bear witness to the origin of the sediments.

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Paleobotanical Department, Swedish Museum of Natural History.

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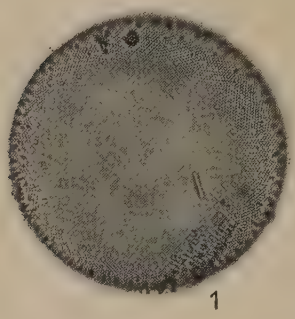
# PLATES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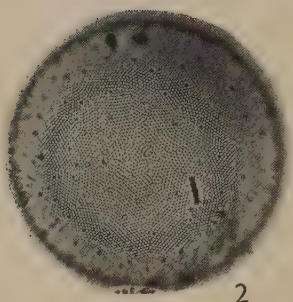
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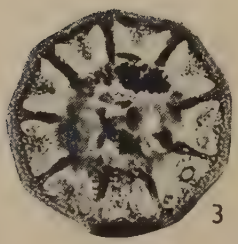
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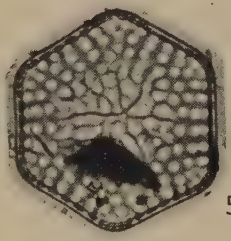
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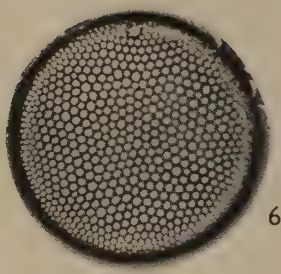
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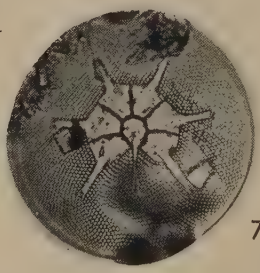
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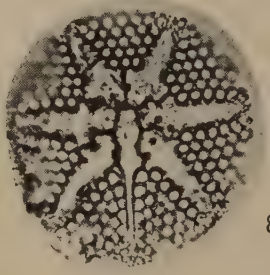
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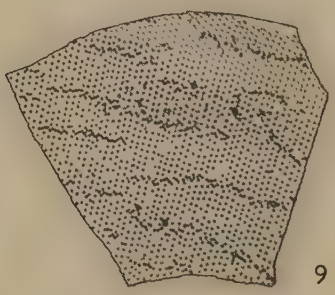
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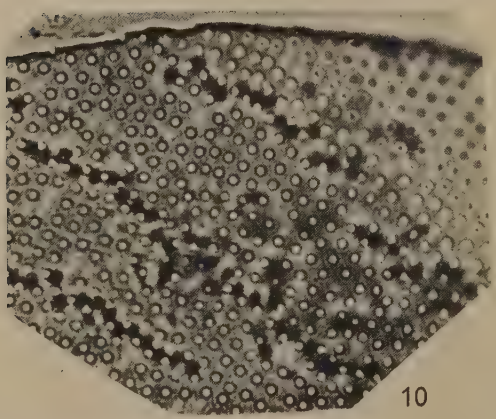
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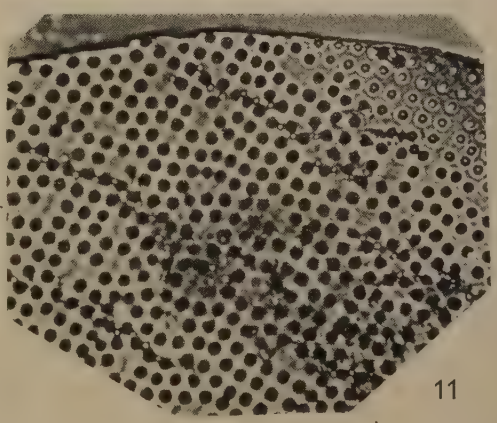
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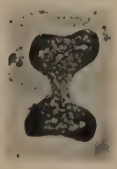
# Plate I.

Fig. 1. *Podosira hormoides* (Mont.) Ktz., focussed on margin ..... 700: 1
Fig. 2. *Podosira hormoides* (Mont.) Ktz., focussed on valve centre ..... 700 :1
Fig. 3. »*Liostephania*» ..... 1000: 1
Fig. 4. *Coscinodiscus reniformis* Castr. ..... 350: 1
Fig. 5. *Stictodiscus parallelus f. hexagona* (Castr.) ..... 700: 1
Fig. 6. *Roperia tesselata* var. *coscinodiscoides* (Mann) ..... 1000: 1
Fig. 7. *Asteromphalus shadboltianus* (Grev.) Rlfs. ..... 500: 1
Fig. 8. *Asteromphalus beaumontii* Ehr. ..... 1000: 1
Fig. 9. Fragment, type 3, (see text, p. 172) ..... 500: 1
Fig. 10. Fragment, type 3, focussed on »normal» areolae (high focus) ..... 1500: 1
Fig. 11. Fragment, type 3, focussed on »large» areolae (low focus) ..... 1500: 1

## Plate II.

Fig. 12. Siliceous epidermal cell, »dumb bell» type ..... 1000: 1
Fig. 13. Siliceous epidermal cell, »dumb bell» type ..... 1000: 1
Fig. 14. Siliceous epidermal cell, »dumb bell» type ..... 1000: 1
Fig. 15. Siliceous epidermal cell, »bâtonnet» type ..... 1000: 1
Fig. 16. Siliceous epidermal cell, »bâtonnet» type ..... 1000: 1
Fig. 17. Group of 3 siliceous epidermal cells ..... 1000: 1
Fig. 18. *Opephora swartzii* (Grun.) ..... 1000: 1
Fig. 19. *Opephora swartzii* (Grun.) ..... 500: 1
Fig. 20. *Actinocyclus elongatus* Grun., long, slender specimen ..... 400: 1
Fig. 21. *Liriogramma hustedtii* nov. sp. ..... 1200: 1
Fig. 22. *Nitzschia kolaczeckii* Grun., frustule ..... 700: 1
Fig. 23. *Nitzschia kolaczeckii*, left valve showing real structure, right valve showing virtual »Pleurosigma» striation ..... 1200: 1
Fig. 24. *Nitzschia aequatorialis* Heid. ..... 1000: 1
Fig. 25. *Nitzschia interrupta* Heid. ..... 1000: 1
Fig. 26. *Nitzschia interrupta*, elongated specimen ..... 1000: 1
Fig. 27. *Nitzschia interrupta*, showing striation ..... 1500: 1
Fig. 28. *Nitzschia marina* Grun., frustule ..... 400: 1
Fig. 29. *Nitzschia marina*, showing carinal dots ..... 1000: 1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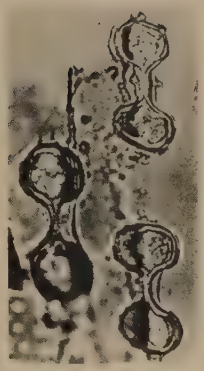
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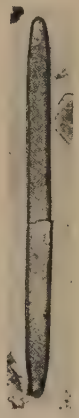
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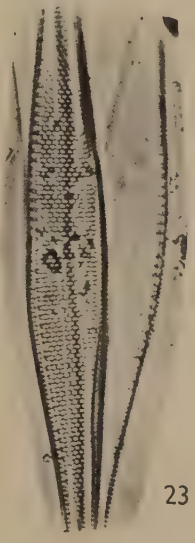
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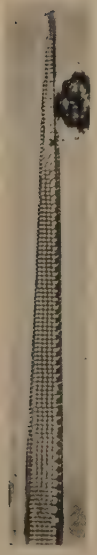
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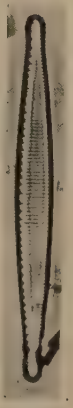
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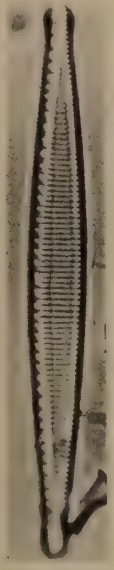
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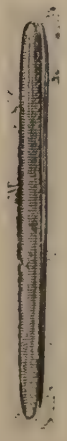
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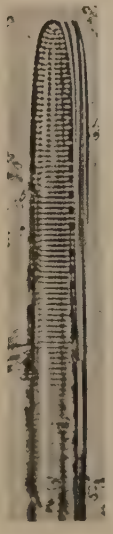
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